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DEPARTMENT OF MINES AND PETROLEUM RESOURCES

HON. DONALD L. BROTHERS, *Minister* P. J. MULCAHY, *Deputy Minister*

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BULLETIN No. 51

Jurassic and Cretaceous Strata of the Bullhead Succession in the Peace and Pine River Foothills

by

J. E. HUGHES

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in right of the Province of British Columbia.
1964

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JURASSIC AND CRETACEOUS STRATA OF THE BULLHEAD SUCCESSION IN THE PEACE AND PINE RIVER FOOTHILLS

SUMMARY

1. Strata of Jurassic and Cretaceous age, described under the general term "Bullhead," outcrop extensively in the Peace and Pine River Foothills, and are well developed in the subsurface of the Peace River District.

2. The Bullhead strata are here reclassified as two groups: the Beaudette Group, a lower marine sequence, 1,000 to 4,000 feet thick; and the Crassier Group, the overlying coal measure sequence, 2,000 to 4,000 feet thick. Both units thicken westward.

3. The Beaudette Group contains, in ascending order: the Monteith Formation, mostly sandstones and quartzites; the Beattie Peaks Formation, interbedded shales, siltstones, and sandstones; the Monach Formation, sandstones with or without the uppermost quartzite member. Facies changes from east to west are shown by an increase in the proportion of sandstones at the expense of quartzites in the Monteith Formation and equivalent strata, and an increase in sandstones in the overlying beds.

4. Three formations are recognized in the Crassier Group: the Brenot and Dresser Formations (new names), and the Gething Formation at the top. These formations are distinguished by the proportions of coal, shale, siltstone, and sandstone, by the nature of their cyclothems, and by the occurrence of thick beds of medium to very coarse grained sandstones with grits and minor conglomerates which characterize the Dresser Formation. This formational subdivision becomes unworkable to the west, at least locally in the Pine Valley.

5. The Beaudette Group can be dated as probable Upper Tithonian, Berriasian, and Valanginian, by Buchia and ammonite faunas. The Crassier Group occupies all, or part of the interval, late Valanginian - Middle Albian. In its upper parts, the Dresser and Gething Formations contain the Luscar - Gething flora, whose range can be stated as probable Aptian - Albian.

6. The interval represented by the quartzite member of the Monach Formation and the Brenot Formation is not well dated by fossils. It likely includes a disconformity. The field evidence indicates that such disconformity can be placed at the boundary of the Beaudette and Crassier Groups, and that it followed a marine retreat at the close of Valanginian time.

7. The Beaudette and Crassier Groups can provide conditions suitable for oil and gas traps in the subsurface. Suggestions for exploration are developed from field observations reported herein. The Beaudette - Crassier Boundary, marked by abandoned littoral or near shore sands, now represented in the quartzite member of the Monach Formation, offers the most favourable target for drilling.

CHAPTER I.--INTRODUCTION

The part of the Rocky Mountain Foothills lying between latitude 55 degrees 30 minutes to 56 degrees 15 minutes north and longitude 121 degrees 30 minutes to 123 degrees 00 minutes west, and generally called the Peace and Pine River Foothills, contains extensive outcrops of Upper Jurassic and Lower Cretaceous strata which are described under the term "Bullhead." The strata are between 3,000 and 8,000 feet thick and compose a lower marine sequence and an overlying coal measure sequence.

In this report of field investigations, the Bullhead strata are reclassified and divided into two groups. The lower marine sequence is termed the Beaudette Group and includes the Monteith, Beattie Peaks, and Monach Formations. The overlying coal measures, here named Crassier Group, contains three formations: the Brenot and Dresser, two new formations recognized in the lower part, followed by the Gething Formation. An account of the stratigraphy of the Bullhead succession, given in Chapter II is followed by descriptions of localities and sections in Chapter III.

FIELD WORK

Mapping of the Pine River Foothills by the writer (1954 to 1958) included work on the Bullhead strata. This was supported by a reconnaissance of the Moberly Foothills (1955). Examination of drill cores from the Peace River Canyon (1959) also provided sections of part of the Bullhead. These cores and survey data were made available by B.C. and B.B. Power Consultants Limited (now renamed International Power and Engineering Consultants Limited), who were then exploring potential damsites in the canyon. Stratigraphic work in the Peace River valley was completed in 1960.

ACKNOWLEDGMENTS

The writer gratefully acknowledges the able assistance of Y. Kawase and K. Newton, K. Falconer, and C. Wright, Y. Kamachi and A. Jellinek in the mapping of the Pine River Foothills; the help and many courtesies of the residents of Hudson Hope and Chetwynd, and the staff of B.C. and B.B. Power Consultants Limited.

The writer extends his appreciation to Prof. C. W. Stearn, McGill University, for critical reading, and advice on the original draft of Chapter II; to Dr. D. L. Griffin, British Columbia Department of Mines and Petroleum Resources, for reading the text; to Dr. J. A. Jeletzky, Geological Survey of Canada, for identifying and dating the Jurassic and Cretaceous faunas; and to Dr. D. C. McGregor, also of the Geological Survey of Canada, for identifying the floras.

PHYSIOGRAPHY

The Foothills are part of the paratectonic system of the Western Cordillera, and were formed by the folding and uplift of the sediments of a miogeosyncline, in an orogeny of post-Cretaceous age.

In the Peace and Pine River areas, the Foothills are a terrain of mountain ranges and high plateau. They are mountainous in the west and merge with the Rocky Mountains without any topographic change. In the east they consist of a plateau which is partly crossed by several ranges of hills. Relief is considerable, 1,500 to 2,000 feet within the major valleys, and in addition 500 to 2,000 feet above the valley shoulders. Mountain summits in the Foothills have elevations of 5,500 to 7,000 feet. Most of the

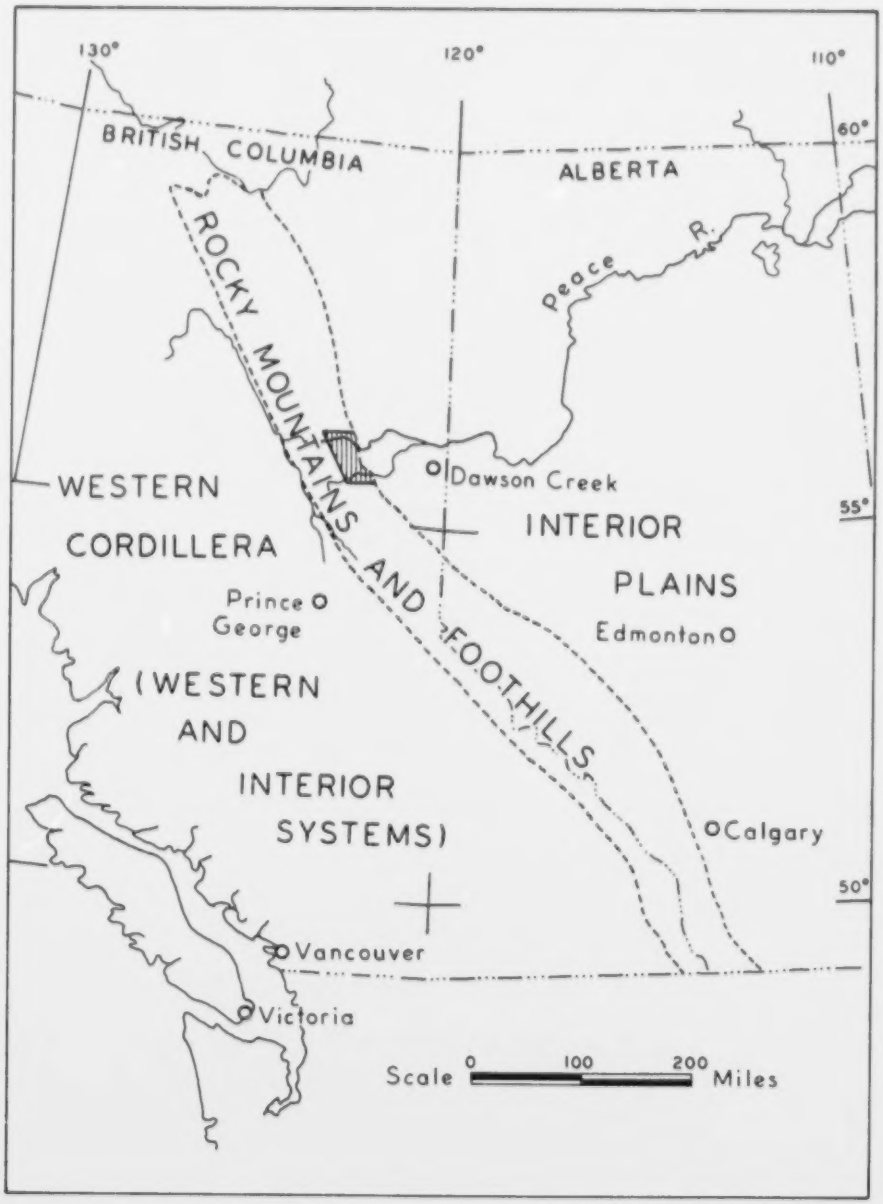

Figure 1. Index map showing Peace and Pine River Foothills (shaded).

area is thickly forested up to the timberline at 4,500 to 5,000 feet elevation, above which the best exposures of Bullhead strata are to be found. Stratigraphic work carried out in the valleys requires areal mapping, because of the limited exposure and the complicated folding.

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CHAPTER II.--GENERAL STRATIGRAPHY OF THE BULLHEAD SUCCESSION

REVIEW

The term "Bullhead Mountain Formation" was given for strata lying between the Triassic and the Fort St. John beds by McLearn (1918, p. 16). The term was intended to exclude the Fernie shales as noted by McLearn in a later definition (1940, p. 17). He divided the formation into two parts (1923, p. 3): an upper coal measure sequence with fine sandstones, shales, and coals, named the Gething Member; a lower member of conglomerates, grits, coarse sandstones, and thin coals. The lower member was considered largely non-marine with some marine parts containing Buchia at the base (1921, p. 3; 1940, p. 71).

Wickenden and Shaw recognized the strata of McLearn's definitions as a group, under the term "Bullhead Group" (1943, p. 2). Then, Beach and Spivak (1944, p. 4) following McLearn's original divisions raised the Gething Member to formational rank, named the lower member the "Dunlevy Formation," and united these formations in the Bullhead Group (see also McLearn and Irish, 1944, p. 2; Spivak, 1944, p. 2). These classifications applied to the eastern part of the Peace and Pine River Foothills.

In the nearby foothills to the west, Mathews (1947) recognized two divisions of the Bullhead Group: the non-marine Bullhead, an upper coal measure sequence of 4,000 to 4,500 feet thick; and the underlying marine Bullhead, 2,000 to 3,000 feet thick. He divided the lower marine sequence into the Monach, Beattie Peaks, and Monteith Formations. The Monteith Formation, in the lower part, was reported to overlie the Fernie Group.

The different classifications were partly reconciled in the belief that the non-marine Bullhead represented an upper part of the Dunlevy Formation, by McLearn and Kindle (1950, p. 63) and Bell (1956, p. 17). Another classification of the Bullhead succession was proposed by Warren and Stelck (1958, pp. 57-60), by adding the Dunlevy, Monach, and Beattie Peaks and Monteith Formations in their entirety to form a "Lower Bullhead" division. The order of succession they have indicated is not supported by this present work. Muller (1961) recognized the formations of the marine Bullhead described by Mathews (1947), but included the non-marine Bullhead under the term "Gething Formation."

A classification of strata in the interval between the Fort St. John beds and the Fernie shales given by Stott (1960) for foothills south of latitude 55 degrees 10 minutes north (a point about 40 miles southeast of the Pine Valley) included terms used in the central and northern Alberta Foothills, the Nikanassin and Cadomin Formations of MacKay (1929, pp. 7 and 9), and also the Gething Formation of the Peace River Foothills after Beach and Spivak (1944). Some later observations by Stott (1962) from the Peace River area indicate a need for reclassifying the Bullhead succession.

In the following account new subdivisions are introduced for the Bullhead strata and new names proposed. Dr. T. E. Bolton checked these names and found them available for stratigraphic use. The writer acknowledges his help on behalf of the Advisory Committee on Stratigraphic Names, Geological Survey of Canada.

Faunas of the writer's collections have been identified by Dr. J. A. Jeletzky of the Geological Survey of Canada. The writer is indebted to Dr. Jeletzky for the identifications and advice on the age of the fossils. The dating of the Cretaceous faunas are referred to the international standard stages of Muller and Schenck (1943), and the Jurassic faunas to the stages proposed by Arkell (1956), unless stated otherwise. The identification of floras, with notes on their stratigraphic affinities, are by

TABLE I

EQUIVALENCE OF CLASSIFICATIONS OF THE BULLHEAD SUCCESSION

PEACE AND PINE RIVER FOOTHILLS

<table>
<tr><th colspan="2">1</th><th colspan="2">2</th><th colspan="2">3</th></tr>
<tr><td rowspan="4">BULLHEAD

GROUP</td><td>GETHING
FORMATION</td><td colspan="2" rowspan="2">UPPER NON-MARINE

BULLHEAD</td><td rowspan="3">CRASSIER

GROUP</td><td>GETHING
FORMATION</td></tr>
<tr><td rowspan="3">DUNLEVY

FORMATION</td><td>DRESSER
FORMATION</td></tr>
<tr><td rowspan="3">LOWER
MARINE
BULLHEAD</td><td>MONACH
FORMATION</td><td>BRENOT
FORMATION</td></tr>
<tr><td>BEATTIE PEAKS
FORMATION</td><td rowspan="2">BEAUDETTE

GROUP</td><td>MONACH
FORMATION</td></tr>
<tr><td>MONTEITH
FORMATION</td><td>BEATTIE PEAKS
FORMATION</td></tr>
<tr><td colspan="4"></td><td>MONTEITH
FORMATION</td></tr>
</table>

(1) McLearn (1918, 1923); Wickenden and Shaw (1943); Beach and Spivak (1944); McLearn and Irish (1944) (2) Mathews (1947) (3) Present Report

Dr. D. C. McGregor of the Geological Survey of Canada. Reference to the reports of Jeletzky and McGregor are provided in the following text.

CLASSIFICATION

The following discussion applies to the Foothills between the Peace and Pine Rivers. The two classifications of Beach and Spivak (1944) and Mathews (1947) are reconciled and their equivalence is shown in Table I. Figure 2 summarizes the Bullhead stratigraphy observed by the writer.

The Bullhead succession occupies the interval between the Fernie Group and the basal Moosebar conglomerate of the Fort St. John Group. This is also the sense and definition employed by earlier workers. The Bullhead succession is divided into two parts: the lower marine strata of sandstones, quartzites, and shales; the upper non-marine coal measures. The division follows Mathews (1947, p. 9). The lower division is named the "Beaudette Group" and the upper division the "Crassier Group." The names are from Beaudette and Crassier Creeks in the Pine Valley.

The separation is useful in mapping. The boundary of the Beaudette and Crassier Groups is distinct, and they form the primary and natural divisions of Bullhead strata in the field. The descriptions "marine" and "non-marine" indicate the main character of the groups, and do not exclude the occurrence of minor units of different origin within them.

The term "Dunlevy Formation" is best discarded. It is unwieldy for mapping, and also for stratigraphic use. The formation as previously defined contains both marine and non-marine sequences which may be separated by a disconformity. It is convenient to retain the term "Bullhead" in the meaning of a "super group" or succession. The nomenclature accepted here for the Peace and Pine River Foothills excludes the term "Nikanassin." The use of this term is inappropriate, or even confusing. Moreover it has been applied for very different units of Jurassic and Cretaceous age (see Beach and Spivak in report of the Alberta Study Group, 1954, p. 27; Warren and Stelck, 1958, Fig. 4; Muller, 1961; compare Stott, 1960; see also Ziegler and Pocock, 1960). The writer is not aware of any lithological unit(s) which can be included in the term "Nikanassin" in this area, certainly not without obscuring an account of the stratigraphy. The term "Cadomin" is also rejected. It is best kept to the original meaning (MacKay, 1929; Lang, 1947 A and B; Alberta Society of Petroleum Geologists, 1960), for the extensive conglomerate recognized under this name is absent from the Peace and Pine River Foothills.

THE BEAUDETTE GROUP

The Beaudette Group comprises the Monteith, Beattie Peaks, and Monach Formations. The Monteith and Beattie Peaks Formations are used in the same sense as Mathews (1947). Usually a quartzite bed occurs at the top of the sandstones of the Monach Formation and in some localities several quartzite beds occur in its upper part. They are not readily separated from the main sandstones below. The top quartzite is overlain by coal measures of the Crassier Group. In a few localities the quartzites have not been found. It is advisable to redefine the Monach Formation to include the upper quartzites. A representative section is therefore given in Chapter III (Section 12).

The formations of the Beaudette Group can be dated by ammonite and Buchia faunas, in the Pine Valley, in the area of the headwaters of Carbon Creek, and adjacent

parts of the Moberly Valley. Fossils are abundant only locally and in thin beds; much of the succession is barren. The same formations can be traced in the valley of the Peace River east of Stott Creek; no faunas have been found here.

In the western part of the Pine Valley the Beaudette Group is recognized as an undivided unit (Section 13). Correlations of the several units comprising the Beaudette Group are shown on Figure 2.

The Beaudette Group follows the Fernie Group with transition. In the upper part of the Fernie Group, black shales pass to a sequence of thinly interbedded shales, silty shales, siltstones, and fine grained sandstones, which ranges from 75 to 150 feet in thickness. This sequence is designated by the temporary and informal term "the transition beds" (of the Fernie Group). They belong to the Upper Jurassic, and are contained within the upper Oxfordian - Kimeridgian - Portlandian (sensu stricto), from the evidence available.

Fossils, referred to the transition beds and collected in float of local or exotic origin at Little Boulder Creek, included:

(i) Buchia mosquensis (Buch, non Keyserling, non Lahusen) (late form)
Buchia piochii (Gabb)?

(ii) Buchia ex gr. B. mosquensis (Buch)--
B. concentrica (Sowerby)

(iii) Pecten (Entolium ?) sp. indet.
Pteria (Oxytoma) sp. indet.

The Buchia mosquensis zone of late Kimeridgian and Portlandian (excepting the latest Portlandian) is represented, and the form of this species in lot (i) suggests the upper part of this zone. Lots (i) and (ii) may be of the same general age but an early Kimeridgian or late Oxfordian age cannot be excluded for the fossils of lot (ii) as they are poorly preserved (Jeletzky, 1962). Fossils of later Tithonian age have not been found in the transition beds of the Fernie Group.

The Monteith Formation

The Monteith Formation can be traced from Big Boulder Creek to Butler Ridge. In the French Petroleum Company - Richfield, Brenot Creek No. 1 Well, it follows a transition of thin interbedded shales, siltstones, and sandstones 75 feet thick overlying shales. These transition beds together with the shales belong to the Fernie Group as already defined.

The Monteith Formation consists of sandstones and quartzites with minor, thin shales. The sandstones include several types: dark grey, argillaceous sandstones; grey, feldspathic sandstones; brownish weathering sandstones; moderately clean sandstones; and sandstones gradational between these types. They are mostly fine to medium grained and thick bedded. In places the sandstones are interbedded with clean quartzitic sandstones and grits,* and quartzites which are very coarse to very fine grained. The

*The term grits is a field term applied to consolidated arenaceous clastic rocks containing more than 20 per cent of granules (size range 2 to 4 millimeters). The residual component of the grits, or matrix, consists of grains in the size range 2 to 1/8 millimeter. Coarse and very coarse sand grains predominate in the matrix, and also occur in association with grits in thin partings and lenses. The grits lack appreciable amounts of pebbles.

The terms conglomerate and conglomeratic are reserved for consolidated sediments containing clastic material of pebble grade (size range in excess of 4 millimeters).

sandstones and quartzites have thin interbeds of black shales with silty and sandy partings. The thickness of the formation decreases from about 1,850 feet in the west to 943 feet in the east part of the Foothills.

The Monteith Formation contains two main lithofacies: (1) brown weathering, argillaceous, and feldspathic sandstones and (2) quartzites with clean sandstones and quartzitic sandstones. Quartzites and quartzitic sandstones replace the sandstones (1) from west to east as the formation thins. In the middle part of the Foothills the quartzites are abundant and become more restricted to the upper third of the formation. In some localities they form a distinct subordinate unit in this interval as at Mount Monteith. Few beds of quartzites and quartzitic sandstones can be traced into the correlative strata of the undivided Beaudette Group in the west part of the Pine Valley, but these sections are only partly exposed or otherwise incomplete due to erosion.

The writer has collected Buchia sp. indet. from the Monteith Formation - identification by Jeletzky (1961). The age of the Monteith Formation is believed to be Upper Jurassic and Lower Cretaceous (Berriasian to early Valanginian). The formation is overlain by strata of early Valanginian age in the middle and western parts of the Foothills.

Collections from the Monteith Formations also included one specimen of the plant Elatides splendida Bell - identification by Dr. D. C. McGregor (1960). The fossil came from quartzites 215 feet below the top of the Monteith Formation at Rainbow Rocks. The significance of this fossil is uncertain, for the species is common in floras referred to an Aptian age by Bell (1956). It seems inadvisable to accept the implied Aptian age without confirmation from larger collections, and more knowledge of the time range of this species, according to McGregor (personal communication). The non-marine origin of the Monteith quartzites is discounted for drifted plant debris is abundant in marine Cretaceous strata in the Foothills.

The Beattie Peaks Formation

The Beattie Peaks Formation follows the Monteith Formation conformably. It consists of thinly interbedded black and dark grey shales with silty, brownish shales, siltstones, thin sandstones, and ironstone bands, together with sandstones in beds 4 to 20 feet thick. The thicker sandstones are fine to medium grained, and increase in amount in the upper third of the formation. Worm markings and casts are common.

The Beattie Peaks Formation is about 1,225 feet thick at the Beattie Peaks, and 950 feet thick at Mount Frank Roy. From this area, the thickness decreases along the structural trend of the Foothills, north-northwestward to 750 feet at Indian Head near the Peace River (Mathews, 1947) and south-southeastward to 650 feet in the east flank of the Bickford anticline at the Pine River. The formation thins eastward to as little as 70 feet at the French Petroleum Company - Richfield, Brenot Creek No. 1 Well, and this section may be near the eastern limit whereat the formation can be properly recognized.

The sandstones contain Dentalium ?, and pelecypods including Buchia, ammonites, and belemnites. Thin Dentalium ? horizons are common, and often include groups of fragmented shells, belemnite guards, and scattered pebbles. A list of the writer's collections follow - identifications by Jeletzky (1957, 1961, and 1962):

Buchia keyserlingi (Lahusen) f. typ.
Buchia cf. keyserlingi (Lahusen) f. typ.
Buchia keyserlingi (Lahusen) var.
(B. crassicollis - like variant)

Buchia cf. keyserlingi (Trautschold) Lahusen
Buchia cf. keyserlingi (Lahusen)
Buchia sublaevis (Keyserling)
Buchia cf. terebratuloides Lahusen
Buchia sp. indet.
Pecten (Entolium) sp. indet.
Pleuromya sp. indet.
Tellina sp. indet.
Arctica ? sp. indet.
Bulla (Tornatina) ? sp. indet.
Polyptychites (Polyptychites) cf. keyserlingi Neumayr and Uhlig, 1881 s.l. (comparable with Polyptychites keyserlingi var. lejanus Bogoslowsky or P. (P.) keyserlingi var. expansus Bogoslowsky)
Polyptychites (Polyptychites ?) sp. indet. (juvenile form)
Polyptychites s.l. ? sp. indet.
Fragments of ammonites belonging to the Holcostephanidae Kilian sensu Roman, 1938
Dichotomites aff. D. quatsinoensis (Whiteaves) and D. oregonensis Anderson
Dentalium ? sp. indet.
True belemnite (Belemnitaceae), genus and species indet.

Polyptychites cf. keyserlingi was obtained 70 feet (stratigraphic interval), above the base of the Beattie Peaks Formation at Mount Frank Roy. The identification strongly favours a late Lower Valanginian age for the containing bed (see international standard stages of Muller and Schenck, 1943), and it excludes an early Lower Valanginian age (the Platylenticeratan of Spath, 1924) while leaving a somewhat remote possibility of a Middle Valanginian age (the Upper Polyptychitan of Spath, 1924), according to Jeletzky (written communication, 1964).

The Polyptychites of indeterminate species can only be referred tentatively to a general Valanginian age (Jeletzky, 1957, 1961).

Jeletzky recognizes a Buchia keyserlingi f. typ. fauna, with B. keyserlingi f. typ., B. keyserlingi et var., to be restricted to the Beattie Peaks Formation, according to the information at hand (1961). He believes this fauna to be early Valanginian age (corresponding to the Platylenticeratan and Lower Polyptychitan ages of Spath, 1924). The overlying Monach Formation contains a different Buchia fauna, characterized by B. n. sp. aff. inflata (Toula) of Mid to Late Valanginian age. Jeletzky (1961) notes that the B. n. sp. aff. inflata fauna ranges down into the upper part of the Beattie Peaks Formation. The stratigraphic boundary between the two faunas has not been determined in any one section. The earlier fauna with B. keyserlingi f. typ., B. keyserlingi et var., does not range above the lower two-thirds of the Beattie Peaks Formation, according to the limited observations in the Pine Valley.

The ammonite, Dichotomites aff. D. quatsinoensis (Whiteaves) and D. oregonensis Anderson, is diagnostic of Mid to Late Valanginian rocks (Upper Polyptychitan of Spath, 1924), although its stratigraphic relationship with the Buchia n. sp. aff. inflata fauna is unknown (Jeletzky, 1962). The ammonite has been collected from the Beattie Peaks Formation by other workers (Jeletzky, 1962). The

specimen reported here is from talus at the foot of Mount Bickford, and its stratigraphic position is uncertain.

Buchia terebratuloides Lahusen is characteristic of the Valanginian stage, more especially the Lower Valanginian (Jeletzky, 1957), but it has been reported to descend into rocks of Berriasian and Upper Tithonian age; it is rare or absent from Middle Valanginian rocks with Dichotomites (s.l.) cf. giganteus. The Buchia forms reported as Buchia sp. indet. are poorly preserved and can only be dated tentatively as Lower Cretaceous (Berriasian and Valanginian), with the possibility of late Upper Jurassic age (Jeletzky, 1961).

The Monach Formation

The Monach Formation overlies the Beattie Peaks Formation conformably. It consists of grey sandstones which weather in buff and brownish colours. A thin flaggy habit on weathering is characteristic (Plate IV). The sandstones are fine to medium grained, and uniform in appearance. In places, more so in the eastern sections, the sandstones are clean, lacking appreciable amounts of clay material. Quartzites occur in the upper part of the formation; they are fine to very coarse grained, with lenses of coarse quartzitic grit, and are unfossiliferous.

The formation is 430 feet thick at the Beattie Peaks. The thickness varies between 400 and 300 feet, perhaps less in the Pine Valley. It decreases eastward to 131 feet at the French Petroleum Company - Richfield, Brenot Creek No. 1 Well, and appears to be absent in some localities in the area of the Butler Ridge. A measured section is described in Chapter III (Section 12).

The Beattie Peaks and the Monach Formations together show characteristics of a marine recession, namely: an increase in the proportion of sandstone beds in the upper half of the Beattie Peaks, followed by a full development of sandstones in the Monach Formation; in places, a coarser grain size, improved sorting, and the inclusion of cleaner sandstones and lenses of quartzite in the main sandstones of the Monach Formation. The quartzites in the upper part of the formation occur as single beds, or as several beds separated by concealed intervals. In some localities the quartzites are thin, and in other places they are absent as in the west flank of the Bickford anticline. The quartzites are considered littoral or near shore deposits which accumulated from place to place, at different phases in the retreat of the sea.

The Monach Formation is overlain by the coal measures of the Crassier Group. In the east flank of the Bickford anticline a coal seam rests upon the Monach quartzites (Plate I). In general the boundary of the Beaudette and Crassier Groups is drawn on the top of the uppermost quartzite of the Monach Formation. Where the quartzites are absent the Monach sandstones are followed by sandstones of the Brenot Formation, or the undivided Crassier Group. These coal measure sandstones form lenticular bodies. They contain much carbonized plant debris, layers of shale and mudstone phenoclasts of angular and lensiform outlines, and have variable bedding (current bedding of long and short sweep, and ripple marking), as in the west flank of the Bickford anticline. At Grant Knob, in the Peace River Canyon, a thin coal seam followed by argillaceous sandstones with plant debris and layers of shale and mudstone phenoclasts with few clay ironstone pebbles, marks the base of the Brenot Formation (Figure 5, Section 3). The Brenot Formation here overlies sandstones with interbedded shales and siltstones. These beds are unfossiliferous, and resemble those in the Beattie Peaks Formation. The thick sandstones and the quartzites of the Monach Formation were not developed at this locality, or they were removed by erosion. A

more complete account of the boundary relations of the Beaudette and Crassier Groups is not available due to lack of clear exposures. A disconformity may be presumed, and the Monach quartzites are likely diachronous.

The Monach quartzites are undated. The sandstones are fossiliferous, but their shells and belemnite guards are often fragmented. Fossils collected from the Monach sandstones have been identified by Jeletzky (1961).

Buchia n. sp. aff. inflata (Toula)
True Belemnites (Belemnitaceae) genus and species indet.
Dichotomites (s.l.) cf. giganteus (Imlay)

Jeletzky comments on their age as follows. Buchia n. sp. aff. inflata appears to be "diagnostic of the Mid to Late Valanginian rocks in the Canadian western interior region and in Arctic Canada. The association of these Buchia forms with Dichotomites (s.l.) cf. giganteus (Imlay) in the lot 41032 confirms this dating as this ammonite appears to be diagnostic of the Upper Polyptychitan and possibly the upper part of the Lower Polyptychitan of Spath (1924), in the Western Cordilleran region of North America. These terms correspond to late Middle or early Upper Valanginian of other workers."

The Beaudette Group in the West Part of the Pine Valley

The Beaudette Group has been mapped as an undivided unit in the west part of the Pine Valley, west of Big Boulder Creek. This is advisable for several reasons. A complete section of the group is not available, and the upper boundary is eroded, or not provable in this local map-area. In addition, the upper boundary of the Monteith Formation is not clear and the thick quartzites marking its top are greatly reduced, or almost absent. The Beattie Peaks Formation is not a recognizable unit in this part. The formation contains an increasing number of sandstone beds from east to west in the Pine Valley.

The Beaudette Group follows the Fernie shales with a transition of interbedded shales, silty shales, siltstones, and sandstones. The transition beds, which are 75 to 150 feet thick, are included in the Fernie Group. The boundary of the Beaudette and Fernie Groups is drawn at the base of the lowest sandstone bed thicker than 5 feet.

North of Le Moray Creek the Beaudette Group includes about 3,000 feet of beds: brown and grey argillaceous sandstones mostly, some quartzitic sandstones with one bed of quartzite in the middle part, together with minor interbeds of shales and siltstones with thin sandstones. A fauna containing:

Buchia cf. uncitoides (Pavlow)
Buchia ex aff. B. keyserlingi (Lahusen) (small early forms)

was obtained about 1,500 feet above the base of the Beaudette Group in this area. Jeletzky, who identified the fossils, suggested a late Berriasian age, and indicated them to be older than those from the lowermost beds of the Beattie Peaks Formation (1961). The preservation of the fossils does not allow a definite dating.

Another collection of fossils from the undivided Beaudette Group, in unmapped ground 10 miles north-northwest of Pyramis Mountain included:

Buchia aff. unschensis (Pavlow)
Buchia cf. keyserlingi var. sibirica (Sokolow)
"Belemnites" genus and species indet.
Pentacrinus ? sp. indet.

The identifications are by Jeletzky (1957, 1961) who tentatively refers the Buchia forms to the uppermost Berriasian, or early Valanginian.

The most westerly section of the undivided Beaudette Group occurs on the north salient of Le Moray Mountain in the Pine Valley. The lower 1,500 feet consists of brown and grey sandstones and argillaceous sandstones; it is fossiliferous. The middle part, 1,500 to 1,775 feet above the base, contains light coloured sandstones and quartzitic sandstones, with few layers of clay galls. The upper 1,775 to 2,250 feet of the section is incompletely exposed. It contains flaggy, brown weathering, argillaceous sandstones; grey, quartzitic sandstones with layers of clay galls, and beds of conglomerate formed of shale and mudstone phenoclasts; together with lesser amounts of shales, mudstones, and siltstones (Section 14). The faunas collected from the lower 1,500 feet of sandstones are reported in descending stratigraphic order as follows:

(iv) Buchia sp. indet. (of early Lower Cretaceous affinities)
Buchia sp. indet.
Pecten (Pseudamusium ?) sp. indet.

(iii) Buchia cf. okensis (Pavlow)
Buchia cf. uncitoides (Pavlow) s.l.
Buchia sp. indet.
Arctica ? sp. indet.

(ii) Buchia ex aff. B. fischeriana (d'Orbigny) and B. okensis (Pavlow)
Buchia n. sp. ex aff. B. volgensis (Lahusen)

(i) Buchia sp. indet. (of uppermost Jurassic or lowermost Cretaceous affinities)
Tellina sp. indet.

Jeletzky (1962) identified the faunas, and the following note summarizes his observations on their ages and affinities.

The lowest fauna (i) from near the base of the undivided Beaudette Group can only be dated as uppermost Jurassic (general Upper Tithonian) or lowermost Cretaceous (early Berriasian) age. The second (ii) appears to be new to the Buchia faunas of North America and northern Eurasia. The occurrence of the listed Buchia forms (ii) can indicate an uppermost Jurassic (late Tithonian) or lowermost Cretaceous (early Berriasian) age. The exact position of this fauna with reference to the zones of B. fischeriana, or B. okensis is uncertain. The third fauna (iii) with B. cf. okensis (Pavlow) and B. cf. uncitoides (Pavlow) s.l. is poorly preserved, but belongs to the basal Lower Cretaceous (early Berriasian). It is probably referrable to the zone of B. okensis. The Buchia sp. in the fourth fauna (iv) shows early Lower Cretaceous affinities.

The faunas (ii) and (iii) may suggest the first indications of the zones of B. fischeriana and B. okensis in the Rocky Mountain Foothills. The following B. uncitoides zone is perhaps indicated in the collection reported from north of Pyramis Mountain (Jeletzky, 1961, 1962).

The transition beds of the Fernie Group belong to the Upper Jurassic, as already discussed. The lower 1,500 feet of the undivided Beaudette Group in the west part of the Pine Valley belongs to part of the Tithonian and the Berriasian stage. The Jurassic-Cretaceous boundary can be placed about the level of the fauna (ii) with Buchia ex aff. B. fischeriana (d'Orbigny) and B. okensis (Pavlow), and Buchia n. sp. ex aff. B. volgensis (Lahusen), or in the underlying interval, and within the lower 1,000 feet of the undivided Beaudette Group.

The lower 1,500 feet of the undivided Beaudette Group are correlated with the main part of the Monteith Formation (of late Jurassic - Berriasian age). The correlation agrees with the stratigraphic successions determined in mapping, as illustrated in Figure 2.

Deposition of the Beaudette Group

Sedimentation in the Beaudette Group can be represented by three lithofacies: (1) quartzites and quartzitic sandstones; (2) sandstones of argillaceous, feldspathic, and ferruginous aspects; (3) shales with siltstones. These are simplified groupings but allow a basis for comments of a preliminary order.

In the coarser clastics, quartz forms the most important detrital components; chert is present in minor amount. Feldspar is not abundant, and seems restricted to the Monteith and Beattie Peaks Formations and the lower parts of the Beaudette Group. Ferromagnesian silicates are rare, and muscovite is probably the most frequent of the heavy minerals. Matrices are composed of quartz, much of it in optical continuity with the detrital grains, microcrystalline quartz, clay material, and carbonates; iron is contained or associated with authigenic carbonates, including siderite. Some fine grained sandstones, siltstones, and silty shales are calcareous. Distinction of the quartzite (1) and sandstone lithofacies (2) rests on the proportion of clay material, and the nature of the authigenic matrix (either quartz or carbonate with or without quartz). In addition, quartzites have a wide range of grain size from very fine to granule grade, while sandstones are mostly fine grained and fine to medium grained.

Continuous deposition prevailed in the Beaudette Group, much of the sediments being derived from westerly sources. These sediments contributed mostly to the sandstone and shale lithofacies (2 and 3). A sudden influx of sands onto the site of the Foothills in Beaudette time indicates uplift and erosion to the west, following reduced sedimentation and relatively stable conditions for much of Jurassic time. The uplift was a phase of the Nevadan orogeny and exposed a metamorphic-igneous terrane. Sedimentary rocks were also exposed in this hinterland.

The distribution of the quartzite and sandstone lithofacies (1 and 2) seems unusual and is unexplained by overlap and offlap of formational units. Mutual replacement and intertonguing of these lithofacies is inferred from observations of interbedding at single localities, and the summary of columnar sections (Figure 2). Sediments of both lithofacies were swept into a miogeosynclinal trough and deposited in beds over thin substrata of dark grey and black shales. The thickness and proportion of the quartzite lithofacies increases from west to east. Its derivation from an easterly source, either whole or in part, must be considered possible, perhaps likely. Other observations may or may not support such view. Quartzites appear to contain more coarse grained material in the eastern sections, but grain sizes range from very fine to granule grade, and are often indeterminate due to cementation by secondary quartz. An east facing dip and set of current bedding seems more frequent, though current bedding is not recognizable everywhere in the quartzites.

Winnowing and clean washing of the quartzite sediments, and the wide range of grain size, point to a depositional environment of high wave and current energy and much reworking. In contrast, greater uniformity of grain size (fine to medium grade) and included clay materials shows that sorting in the sandstone lithofacies was largely dependent on distance from source area. The distribution of lithofacies in the lower parts of the Beaudette Group indicates that the sandstones filled the middle part of the

miogeosynclinal trough where subsidence was more continuous. The quartzites accumulated on, or close to, the eastern shelf of the trough. This shelf underwent only intermittent subsidence and tilting. Shallow water environments were more frequent here. Sediments from all sources were transferred and reworked across this shelf, and finally deposited as quartzites and the quartzite lithofacies. The transference and reworking of the sediments perhaps took different directions, initial transport to the west, and subsequent reworking from west to east before deposition was completed.

The shale-siltstone lithofacies (3) of the Beattie Peaks Formation marks a general subsidence following the accumulation of sandstones and quartzites. It is uncertain that subsidence occurred everywhere at the same time. Sand deposition still extended into the miogeosynclinal trough, and later increased and became continuous. The Monach Formation records the shallowing, and filling of the trough by late Valanginian time. The sea retreated and left behind bodies of quartzose sands, now represented by the upper member of the Monach Formation. Clear exposures of the contact of the Beaudette and Crassier Groups are very few. Possibilities of finding sections revealing interbedded sequences of quartzites, littoral, estuarine, and continental beds of intermediate age, should be allowed. Variable development and discontinuity of the Monach quartzites indicates that: the marine retreat was perhaps a protracted event marked by temporary halts and readvances; or that their sediments were reworked prior to Crassier deposition.

The Beaudette Group, and its individual formations with the possible exception of the Monteith, attains a maximum thickness about a northeast-southwest axis passing through the divide of the Carbon and Moberly drainage, in the area of the Beattie Peaks, Mounts Monteith and Frank Roy (from the observations of Mathews, 1947; and the writer, Figure 2). Differential subsidence and increased sedimentation in an embayment across the cratonic shelf of the Rocky Mountain miogeosyncline occurred throughout post Devonian to Upper Cretaceous time, in the Peace and Pine River areas (Warren and Stelck, 1958; writer MS.). This depositional embayment was localized between the Peace and Murray Rivers, and can be traced by isopachous mapping of formations in the subsurface of the Plains. The axis of the embayment was aligned west and southwest, transversely to the depositional trends, and the present structural trend of the Rocky Mountains and Foothills. The western extension of the former embayment across the site of the Foothills remains to be proven by extensive stratigraphic mapping, but is indicated for the Beaudette Group by its local thickening about the Carbon-Moberly divide. Faulted sections and their unfavourable distribution impede conclusions on the role of the embayment in Crassier deposition.

THE CRASSIER GROUP

The Crassier Group represents a period of coal measure sedimentation, seemingly without any major breaks, or discontinuity. Its subdivisions, the Brenot, Dresser, and Gething Formations, are distinct in the eastern part of the Foothills but require some arbitrary definition in mapping. The boundaries between the formations are transitional in most places, and are considered to be diachronic. The Brenot Creek Formation is marked by thin repetitions of shale, siltstones, and sandstones. The continuity of sedimentation was interrupted in mid Crassier times by local erosional breaks which were followed by the spread of coarse sands and gravels. The sands and gravels formed lenticular and discontinuous bodies and were probably fluvial and deltaic deposits. This sedimentation was characteristic of the Dresser Formation. The Gething Formation includes more regular cyclic deposits. The subdivision of the Crassier Group may be

less easily obtained and perhaps impracticable in its western exposures in the Foothills.

The Crassier Group has a complex lithology, shown by assemblages and cyclothems of shales, mudstones, coals, siltstones, sandstones, grits, and conglomerates. The argillaceous rocks include the seat earths, underclays, and roof shales. Most of the coals are banded. In places, fine grained sandstones of the Crassier Group are ferruginous, and rust flecked in weathered exposures; they contain carbonate and siliceous matrices and also authigenic siderite. In the field, they can be distinguished from sandstones of the Beaudette Group primarily by their association with coal and coal measure cyclothems, and also in detail by their smaller span of ripple marking and current bedding, their irregular and rough bedding surfaces, and often by the abundance of plant debris.

The Brenot Formation

The formation lies between the Beaudette Group and the Dresser Formation above. The formation is poorly exposed; the only complete section is obtained in the French Petroleum Company - Richfield, Brenot Creek No. 1 Well (latitude 56 degrees 06 minutes north and longitude 122 degrees 09 minutes west). The formation was drilled in the interval 3,715 to 4,074 feet in a section with uniform dips, and this interval is taken as the type section; the name is from Brenot Creek which flows from Butler Ridge. The type section is described from drilling cuttings,* as summarized in Figure 4 and reported in Section 2. The Brenot Formation is 343 feet thick in the bore section in the well. It increases in thickness westward, and is about 750 feet thick on the east flank of the ridge at Mount Bickford.

The Brenot Formation consists of coal measures and includes much fine and very fine grained sandstone and siltstone. The sandstones are of two types: fine to medium grained sandstones with light and dark grey chert grains and quartz grains; fine and very fine grained grey and dark grey argillaceous sandstones. The remainder consists of dark grey shales and mudstones, silty shales, carbonaceous shales, and coals. The same lithology is found in outcrop and can be seen at Grant Knob (Section 4) and Rainbow Rocks (Figure 6).

Thin bedding of sandstones, siltstones, and shales is characteristic. In addition, sandstones, with minor shales, silty shales, and siltstones in thin interbeds, may form units 10 to 25 feet thick in different parts of the section from place to place. Sandstones increase in amount to the west.

Exposures of the Brenot Formation reveal mostly sandstones; a few are clear enough to show its full character. Cyclic deposition was common, in the order: fine grained, argillaceous sandstones; thin beds of silty and sandy mudstones, with coarse plant debris (seat earths); coals; thin fissile, carbonaceous shales (roof shales), passing upward to mudstones and shales; thinly interbedded shales and sandstones. The cyclothems are thin, usually 2 to 8 feet. Many are incomplete, lacking coals, and some lack distinct seat earths and roof shales as well. Plant debris, coalified remains, and imprints of woody material are abundant in these beds. Well preserved fossil leaves are rare. The thin cyclothems and many repetitions of barren sequences may suggest recurrent tectonic disturbance of slight intensity, and possibly deposition in an enclosed basin.

Only one set of collections from the Brenot Formation has merited submission

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*Samples of the drilling cuttings are available for study at the Geological Survey of Canada, Calgary; and the Department of Mines and Petroleum Resources, British Columbia, both at Victoria, and the Field Office at Charlie Lake near Fort St. John.

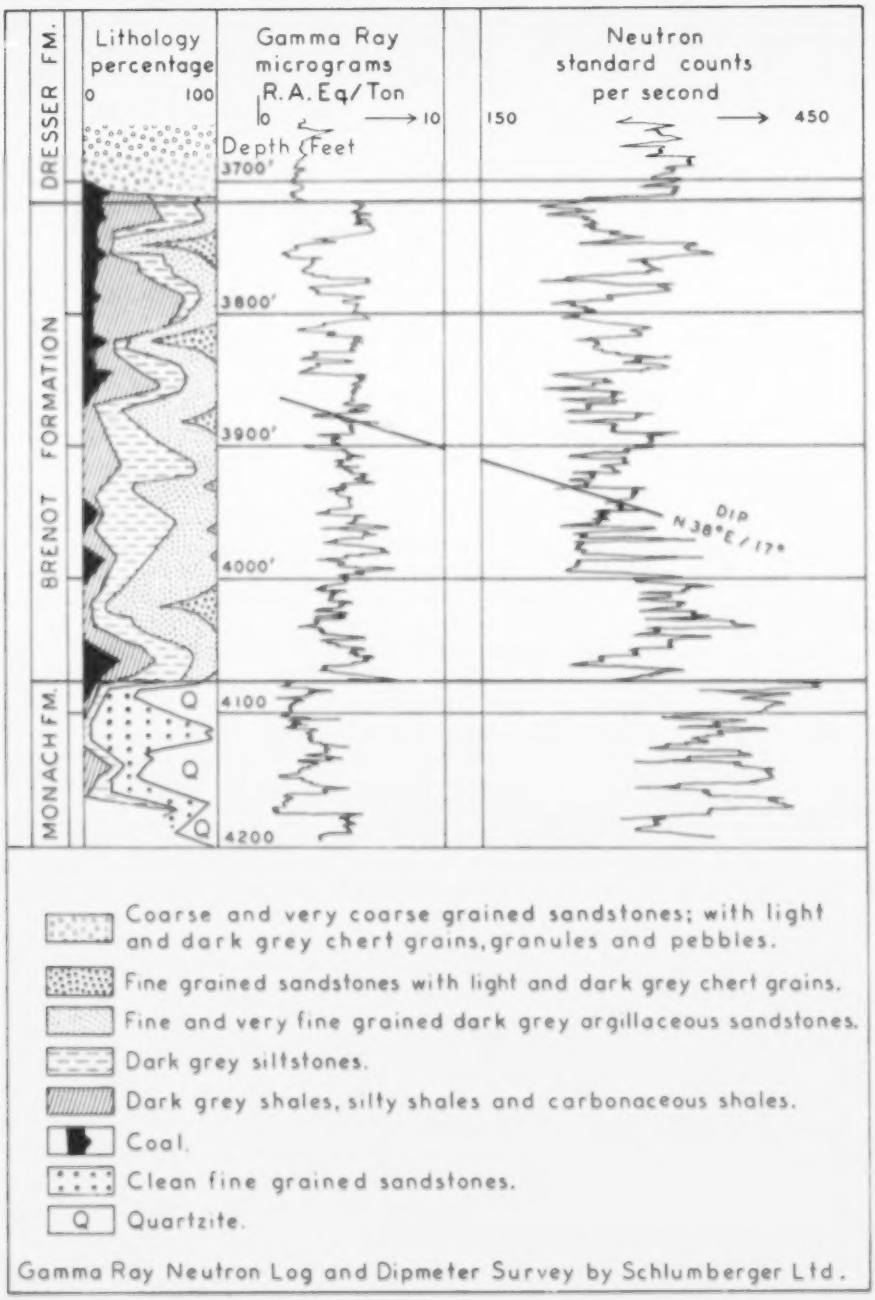

Figure 4. The Brenot Formation: Type section.

for identification. It included:

Pityophyllum cf. P. nordenskiöldi (Heer) Kryshtofovich
Unidentifiable conifer
Drifted fragments of wood, unidentifiable wood

The identifications are by Dr. D. C. McGregor (1961). Pityophyllum cf. P. nordenskiöldi occurs in the Kootenay Formation, the lower flora of the Blairmore Group, and also in floras of the Luscar and Gething Formations. It indicates only a Neocomian or Aptian age from the account by Bell (1956, p. 112).

The formation differs from the Gething Formation in its greater proportion of sand and silt, and thinner bedding. It differs from the Dresser Formation overlying it, in the absence of the thick beds of medium to very coarse grained sandstones with grits and conglomerate, and in its lesser proportion of coarse clastics. The formation is mapped above the quartzites and sandstones of the Monach and below the prominent sandstone and grit beds of the Dresser Formation. In places the upper boundary is distinct and can be put at the base of the lowest thick grit and sandstone bed of the Dresser Formation, as in the Brenot Creek well (Figure 4). In other places the upper boundary is a transition containing thin beds of coarse sandstone and grits.

The Dresser Formation

The type section is at the west end of the Peace River Canyon, and extends 2 miles downstream from the entrance of the Canyon (Figure 5 and Plate II). The lower boundary of the formation is not exposed here. The formation can be traced from the Canyon to Grant Knob, south of Portage Mountain. At this locality the Dresser Formation underlies the Gething Formation, and overlies the Brenot Formation. Geographic names in the vicinity of the type section are pre-empted, or liable to confusion with others already in the literature. The formation is therefore named after Dresser Creek; the formation outcrops on the creek and thence along Butler Ridge to the Peace River Canyon.

The Dresser Formation has been drilled in the type locality and its boundaries established in diamond-drill cores. The description of the type section is taken from these cores (Section 7).* The formation is easily recognized in the field. It is resistant to weathering and forms ridges, or cliffs, as at the Rainbow Rocks on the north bank of the Peace River.

Very coarse to medium grained sandstones and grits are characteristic of the Dresser Formation. They form beds of 10 to 40 feet thick. The sandstones and grits have a speckled appearance which is due to abundant light and dark grey chert grains as well as quartz grains. They are current bedded; in places layers of pebbles mark the base of the foresets. Slump bedding is rarely present. The formation may contain one, or a few beds of conglomerate more than 10 feet thick, but these are absent at some localities. The conglomerates have pebbles of light and dark grey and brownish chert, and some quartzite; the pebbles are commonly less than 1 inch in diameter. The coarse sandstones and grits, and conglomerates, are lenticular bodies and not persistent. They

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*The cores are presently held by the Department of Mines and Petroleum Resources Field Office at Charlie Lake near Fort St. John.

are separated by coal measures containing: dark grey shales and mudstones; thin interbedded shales, siltstones, and fine grained sandstones; fine grained sandstones; thin beds of argillaceous, silty sandstones, and sandy mudstones (seat earths); thin layers of soft grey mudstone (underclays); coals; black, fissile, carbonaceous shales (roof shales). Altogether the sandstones make up more than two-thirds of the formation. The coarse sandstones and grits form more than one-third, or as much as one-half of the formation. The intervening coal measures consisting of shales, siltstones, and medium and fine grained sandstones, form units up to 60 feet thick.

Conditions of deposition in the Dresser Formation are noted from cored sections at the type locality. In places, coal seams are missing due to penecontemporaneous erosion and restricted area of deposition. Splitting of coal seams is common. Eroded and scoured surfaces, relief up to 1 foot, mark the contact of the very coarse to medium grained sandstones and grits with underlying coal measures. Individual beds of these sandstones and grits vary in thickness in this local area. Parts of these beds form the lateral stratigraphic equivalents of fine grained sandstones, and sandstones with siltstones and shales. Some of the very coarse to medium grained sandstones and grits truncate the underlying coal measures so forming washouts. The washouts are of slight order but one example shows the removal of 37 feet of strata including seven thin coal seams. The coal measure forests underwent repeated subsidence and flooding. The very coarse to medium grained sandstones with grits, represent the fluvial and deltaic deposits of rivers entering lakes and swamps. Finer clastic material filled the centre of the lakes. Later forests grew on the upper levels of these deposits. Seat earths underlie the coal seams and consist of argillaceous, silty and sandy beds, followed by upper layers of soft, grey mudstones containing listric surfaces (the underclays). The seat earths contain coarse plant debris and carbonized traces of "rootlets." They follow upon sandstones, or more rarely shales of the coal measure sequences. Thin layers of black, fissile, carbonaceous shale (roof shales) above the seams represent the first phase of subsidence and inundation of each cycle. Deposition of course sands and gravels attained a maximum in Dresser time. They record contemporary uplift in the west in the site of the Foothills. The uplift brought about the erosion of a wide area of sedimentary rocks, as indicated by the abundance of detrital chert in the Dresser Formation. This area of sedimentary rocks probably lay east of the source of the Beaudette sediments, in the hinterland of the Rocky Mountain miogeosyncline. Feldspars are absent from the coarse clastics of the Dresser Formation, and seem uncommon in the sediments of the Crassier Group generally. Pebbles and grains of argillaceous and sideritic rocks occur in the sandstones of the Dresser Formation, and mostly resulted from penecontemporaneous erosion of its sediments.

A few beds of coarse grained, speckled sandstone with minor conglomerate, characteristic of the Dresser Formation, are included in the lower part of the Gething Formation, where they become more widely separated and dispersed. The boundary of the Gething and Dresser Formations is then drawn to include the major development of sandstones in the Dresser Formation. In the western part of the Peace River Canyon it is placed on the top of the Larry sandstone,* and therefore 170 to 210 feet above the base of the Gething Formation as proposed by McLearn and Irish (1944, pp. 2, 8). The coal seams in the Dresser Formation are thin with the exception of the Murray seam of

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*The Larry (Creek) sandstone is an informal stratigraphic term for a sandstone bed found at the west end of the Peace River Canyon (McLearn and Irish, 1944). The sandstone is not recognized outside this locality.

5 feet.

A small flora from the Dresser Formation at Grant Knob included:

Elatides curvifolia Bell
Elatides splendida Bell
Pterophyllum plicatum Bell
? Pterophyllum rectangulare Bell

The identifications are by Dr. D. C. McGregor (1961) who notes the fossils are common Luscar and Gething species. The Luscar-Gething flora was dated as Aptian by Bell (1956). Its full range may include Barremian, Aptian, and early Albian stages (Bell, 1956; Stott, 1962; see under "Age and Correlation").

The thickness of the Dresser Formation ranges from about 1,200 to 700 feet from west to east.

The Gething Formation

The Gething Formation is distinguished by its greater proportion of shales, and numerous coal seams. It contains dark grey shales and mudstones; siltstones; sandstones; thin beds of brownish-grey, sandy and silty mudstone and argillaceous silty non-bedded sandstone, with coarse coalified plant debris and "rootlets" (seat earths); thin beds of soft, grey mudstone containing listric surfaces (underclays); coal seams; thin layers of black, fissile, carbonaceous shale with fine plant debris, and few fossil leaf prints (roof shales). Clay ironstone banding is also present. Pyrite occurs in the seat earths. The sediments were deposited in the cyclic order listed above. This simple sequence is not always present, for some cycles were modified by intertonguing of shales and sandstones, or by a reduction or omission of sandstones. Cyclothems are mostly obtained in intervals of 5 to 25 feet. Coal seams may be up to 5 feet thick; not many of them exceed 10 feet. Close grouping and pairing of coal seams is found in places. The sandstones are mostly very fine to fine grained, and thin bedded. These sandstones form beds up to 15 feet thick. The lower part of the Gething Formation includes coarser grained sandstones and grits with minor conglomerate. The proportion of all sandstones decreases upward within the formation.

The depositional sequences of the Dresser Formation continued into Gething time. Subsidence, inundation, infilling of lakes by clays, silts, and sands, and forest growth provided corresponding cyclothems. Tectonic conditions became more stable, and allowed development of thicker and more complete cyclothems in the Gething Formation. Coal seams are thicker and more extensive. The spread of coarse deltaic sands and gravels became sporadic and then retreated from the site of the Foothills. Extensive shallow water lakes, swamps, and forests characterized the environment of Gething deposition. Mud cracks, ripple marking, fossil tree stumps and dinosaur tracks also record this environment (Sternberg, 1932; McLearn and Kindle, 1950). Probably the sea gained intermittent, or occasional connection with the shallow lakes in later Gething time. A small fauna, collected in situ, 150 feet below the top of the Gething Formation at Fisher Creek, contained Corbula sp. indet., Mactra ? sp. indet., Astarte ? sp. indet., Tellina ? sp. indet., and Unio ? sp. indet., and other pelecypods. Jeletzky (1956) identified the fauna and noted its marine or brackish water aspect. The shells, from one layer in dark grey mudstone, do not show marks of abrasion, or transport prior to deposition. A report of Monotis subcircularis as a derived fossil in the Gething Formation (McKechnie, 1956) indicates that Triassic rocks were uplifted and formed a land area west of the site of the Foothills, during deposition of the Crassier sediments.

The fossils collected from the Gething Formation are listed.

Pine Valley: Fisher Creek

Cladophlebis virginiensis Fontaine emend. Berry
? *Coniopteris brevifolia* (Fontaine) Bell
Elatides curvifolia (Dunker) Nathorst
Ginkgo pluripartita (Schimper) Heer
Pityophyllum cf. *P. nordenskiöldi* (Heer) Kryshtofovich
Podozamites lanceolatus (Lindley and Hutton) Schimper
cf. *Pterophyllum rectangulare* Bell

Pine Valley: near Narod Creek

Thallites blairmorensis (Berry) Lundblad
Cladophlebis strictinervis (Fontaine) Bell
Cladophlebis virginiensis Fontaine emend. Berry
? *Sphenopteris göpperti* (Dunker) Seward
Sphenopteris latiloba Fontaine
Pityophyllum cf. *P. nordenskiöldi* (Heer) Kryshtofovich
Podozamites lanceolatus (Lindley and Hutton) Braun
Sagenopteris sp.
Elatides splendida Bell

Pine Valley: Crassier Creek

Podozamites lanceolatus (Lindley and Hutton) Schimper
Elatides curvifolia Bell
Sphenopteris latiloba Fontaine

Peace River Canyon

Athrotaxites berryi Bell
Fragments, probably *Podozamites lanceolatus*
Possibly *Podozamites lanceolatus*
Probably *Podozamites lanceolatus* and
Pityophyllum cf. *P. nordenskiöldi*

The identifications are by McGregor (1960, 1961). The collections contain species of the Luscar-Gething floras and the lower flora of the Blairmore Group, as listed by Bell (1956). These floras were assigned to the Aptian, but their range may be longer, ? Barremian to Albian (Bell, 1956; Stott, 1962).

The Gething Formation is of the order of 1,050 to 1,300 feet thick in the Peace River Canyon, and is between 1,600 and 1,800 feet thick in its eastern outcrops in the Pine Valley. It is overlain disconformably by the basal conglomerate of the Moosebar Formation (Fort St. John Group). The age of the lower four formations of the Fort St. John Group (Moosebar, Gates-Commotion, Hasler, and Goodrich Formations) is generally accepted as Albian, from the evidence of marine faunas (McLearn and Kindle, 1950; Stelck, Wall, Bahan, and Martin, 1956; Reeside and Cobban, 1960).

The Crassier Group in the West Part of the Pine Valley

The formations of the Crassier Group are more clearly differentiated in the eastern Foothills and these divisions can be maintained as far west as Mount Bickford in the Pine Valley. Further west, equivalent units can be recognized, but without sufficient precision to merit formational status. This is due to several factors. Toward the west there was a change in sedimentation. The assemblage of coarse sands and grits with pebbles, which determined the characteristic lithology of the Dresser Formation, became more distributed throughout the coal measure sequence, and there was a general increase in sand of all grain sizes in the Crassier Group. The exposure is poor and not sufficient to define the stratigraphy in the folded and faulted ground of the west part of the Pine Valley. Reliable stratigraphic horizons are lacking and the coarse sandstones and grits are not persistent. The base of the Crassier Group is exposed in the cores of a few folds but its upper contact has been eroded.

The sediments of the Crassier Group filled part of a miogeosynclinal trough, and spread across its eastern cratonic margin. The miogeosynclinal shelf underwent differential subsidence and downtilting. They attained their maxima on the west border of the shelf and along the trough axis. Sedimentation accompanied subsidence. Over the east part of the shelf, subsidence and sedimentation were reduced, stillstands and erosional phases of the sedimentary cycles more frequent and protracted, and deposition was relatively condensed. These factors of tectonic control account for the concentration of medium to coarse grained sandstones and grits represented in the Dresser Formation in the eastern sections, and therefore the better definition of formational units in the east part of the Foothills.

AGE AND CORRELATION

The Bullhead succession contains a lower marine sequence and overlying coal measures, in the Peace and Pine River areas. It is therefore possible to correlate the Bullhead strata in its eastern and western exposures. Uncertainties of local correlation were implicit in the previous dual nomenclature of the Bullhead (see discussion by McLearn and Kindle, 1960, p. 63). Correlations of the formations of the Beaudette and Crassier Groups, from east to west across the Foothills, have already been discussed, and are summarized in Figure 2.

It should be pointed out that the stratigraphic divisions of the Beaudette Group in the east part of the Peace River Foothills are presently undated by fossils and the correlations, presented in Figure 2, are based on lithology. The extreme eastern section, at the French Petroleum Company-Richfield, Brenot Creek No. 1 Well, approaches a limit at which the Beattie Peaks and Monach Formations can be distinguished from the remainder of the Beaudette Group.

The Beaudette Group appears to form a continuous marine sequence from Upper Jurassic to Lower Cretaceous, including part of the Tithonian, the Berriasian, and most of the Valanginian stage.

The Crassier Group is overlain by Albian beds of the Fort St. John Group. In the Crassier Group, the Gething Formation contains the lower flora of the Blairmore Group, and that of the Luscar Formation, for which Bell has long considered an Aptian age; however the dating of this flora is not settled for a Barremian age was not excluded (1956, pp. 10, 17). Stott (1962, p. 35) reported a new discovery of this flora from the lower part of the Commotion Formation. Its upper range into the Middle Albian was

thereby indicated. Collections from the undivided non-marine Bullhead (the Crassier Group) by Mathews (1947) were included in the lower flora of the Blairmore and the Gething-Luscar flora, and assigned to the Aptian by Bell (1956, pp. 17-19). The collection reported from the Dresser Formation contains species of this same flora according to McGregor (1961), and the lists given by Bell (1956); it is thereby dated as Aptian-early Albian. The Brenot Formation can only be referred to a late Neocomian, and Aptian-early Albian age. No stratigraphic discontinuity or disconformity has been found in the Crassier Group by the writer. One local "unconformity," or perhaps a washout, was observed by Mathews, but the floras above and below this break were of the same age (1947, p. 12). Otherwise, no disconformities were recognized by previous workers. Minor sedimentary breaks abound in the Crassier Group. They are a common feature of coal measure and paralic sedimentation.

Bullhead strata were mapped as an undivided unit north of the Peace River by Hage (1944). The same beds are not recognized in the Foothills north of latitude 58 degrees 00 minutes north. The Beaudette and Crassier Groups occur in the subsurface of the Peace River Plains. Several classifications of these beds have been made using subdivisions of Gething, Cadomin, Nikanassin, Dunlevy, Bullhead, and Blairmore "units." The Gething Formation has been distinguished here by Pugh (1960).

In the Alberta Foothills the Nikanassin Formation contains marine beds with Buchia, and in the upper part non-marine beds and coal measures (Lang, 1947A, p. 8; Irish, 1954, p. 25). The lower beds are known to contain Buchia mosquensis (Jeletzky, 1962). They are correlated, at least in part, with the transition beds of the Fernie Group in the Pine Valley. The upper plant-bearing beds of the Nikanassin contain a flora of Kootenay affinities, and were dated as Neocomian-Barremian by Bell (1956). This Kootenay flora has never been recognized in the Peace and Pine River Foothills. Therefore no satisfactory correlation of the upper beds of the Nikanassin Formation and beds of the Beaudette and Crassier sequences can be proposed. In the Alberta Foothills the Nikanassin is overlain by the Cadomin Formation which consists of one or two conglomerates. The Nikanassin and Cadomin Formations are usually thought to be separated by a disconformity. The Cadomin is succeeded by the coal measures of the Luscar Formation. The Luscar Formation is correlated with the Gething and Dresser Formations on the basis of their common flora (see Bell, 1956). Moreover, a correlation of the Cadomin Formation and the lower conglomeratic and sandy beds of the Luscar Formation, with the Brenot and Dresser Formations is possible, but assumes a change of facies. The Dresser Formation - coal measures marked by the incursion of sands and some gravels - is not similar to the Cadomin Formation.

Two views of the relationship of the Beaudette and Crassier Groups are possible; they are summarized as follows.

(1) The Beaudette Group and the lower beds of the Crassier Group were deposited in continuous order, and there is no disconformity between them. The age of the Crassier Group may then range from late Valanginian to early Albian or occupy parts of this interval. This view assumes the dating by floras is only sufficient to allow a late Neocomian - Aptian - early Albian age. It also includes the possibility of a diastem below beds containing the Luscar-Gething flora, that is, within the interval represented by the Brenot and the lower part of the Dresser Formation.

(2) The Beaudette and Crassier Groups are separated by a disconformity equivalent

to part or all of late Valanginian, Hauterivian, Barremian, and (?) Aptian time. A similar possibility was also noted by McLearn and Kindle (1950, p. 72).

The writer is inclined to the second view from the evidence so far assembled.

CHAPTER III.--DESCRIPTION OF LOCALITIES AND SECTIONS

INTRODUCTION

Bullhead strata were first named from the Peace River Foothills, and were mapped and described in this area by McLearn (1923, 1940), McLearn and Irish (1944), Beach and Spivak (1944), Mathews (1947), and in the Pine River Foothills by Williams and Bocock (1932), Wickenden and Shaw (1943), Spivak (1944), Mathews (1947), and McKechnie (1955). The following descriptions cover previously mapped areas as well as new ground, and illustrate the continuity and changes of the Beaudette and Crassier Groups, westward across the Foothills.

The area between Mount Frank Roy and the Monach, about the headwaters of Carbon Creek, may be regarded as a suitable type area for the formations of the Beaudette Group (see Mathews, 1947). In the Crassier Group, the Brenot and Dresser Formations are referred to type sections. McLearn (1923) named the Gething member (now called the Gething Formation) from the Peace River Canyon, upstream from Grant Flat. Maps by Muller (1961) and Irish (1962) show the distribution of Bullhead strata, but in some different terms from those used by earlier workers, and from those used in this report.

THE FRENCH PETROLEUM COMPANY - RICHFIELD BRENOT CREEK NO. 1 WELL

The Brenot Creek No. 1 well, drilled in 1957-1958 by the French Petroleum Company, was abandoned at a depth of 7,796 feet in Triassic beds, without any discovery of petroleum or natural gas. The geophysical records include gamma ray-neutron and dipmeter surveys (Schlumberger Well Surveying Corporation).

The location of the well is latitude 56 degrees 06 minutes 24 seconds north, longitude 122 degrees 09 minutes 12 seconds west, near the headwaters of Brenot Creek, on the west flank of Butler Ridge. The well was sited on a subordinate anticline of the Butler Ridge anticlinorium, mapped by Beach and Spivak (1944).

Figure 3 illustrates an appreciation of the structure in the well bore. Part of this section is folded and repeated by faulting. The fault, or fault system, is concealed at the surface by a thick drift cover, and is not shown in the Dunlevy-Portage Mountain map sheet (Beach and Spivak, 1944).

The well section contains two parts of different structure. (1) In the upper part, from surface to a depth of 3,000 feet, beds of the Crassier Group are closely folded and thrust faulted. The well was spudded in the Dresser Formation, bent in a narrow box form anticline. (2) In the lower part, below 3,000 feet, the drill cut the Dresser, and Brenot Formations of the Crassier Group, the Beaudette and Fernie Groups, and the Triassic, lying in simple order. Strata in this lower interval are slightly tilted or warped. The recorded dips are about 18 degrees at 3,210 feet, and they decrease downward. The lowermost beds are almost flat lying; a single exception may be given by a dip of 27 degrees between 7,082 and 7,090 feet.

Drill cuttings from the lower part of the structure, in the interval 3,320 to 5,440 feet, therefore provide a section of the Crassier and Beaudette Groups, as summarized in Table II. Stratigraphic divisions in this interval are based on: (1) the shale-siltstone-sandstone ratio, and (2) the characteristic assemblage of sediments, or type of sediment (for example, coal, quartzite, and the different sandstones). Formations are listed in the combined lithological log and gamma ray-neutron log (Figure 3).

TABLE II

STRATIGRAPHIC DIVISIONS IN THE FRENCH PETROLEUM COMPANY - RICHFIELD BRENOT CREEK NO. 1 WELL

INTERVAL 3,320 TO 5,440 FEET

Group	Formation	Depth (Feet)	Interval (Feet)	Thickness (Feet)	
Crassier	Dresser	3,715	+395	+378	+721
	Brenot	4,074	359	343	
Beaudette	Monach	4,210	136	131	1,144
	Beattie Peaks	4,283	73	70	
	Monteith	5,250	967	943	
Fernie	Transition Beds	5,328	78	75	
	"Fernie Shales"				

The Dresser and Brenot Formations are distinct. Stratigraphic divisions assigned to the Monach and Beattie Peaks Formations are thin, but they preserve the characteristic lithologies of the outcrop sections. The Monteith Formation is well developed. Quartzites and quartzitic sandstones occur throughout the formation, and are abundant in the upper and lower third parts. The Monteith Formation overlies shales, siltstones, and sandstones of the transition beds of the Fernie Group.

The interval 3,715 to 4,074 feet represents the type section of the Brenot Formation, which is described in Section 2.

Section No. 1

French Petroleum Company - Richfield, Brenot Creek No. 1 Well:

Interval 3,320 to 5,440 Feet

Interval (Feet)	Description of Drill Cuttings
	Crassier Group
	Dresser Formation
3,320 to 3,350	Sandstones, mostly medium to very coarse grained; speckled appearance due to dark coloured chert grains. Grits, and conglomeratic layers shown

by fragments of chert and quartzite granules and pebbles.

3,350 to 3,390 — Sandstones and grits, continuous with above. Few dark grey shales. Some coals.

3,390 to 3,470 — Shales, dark grey; carbonaceous shales and silty shales. Siltstones, dark grey. Few sandstones, very fine to fine grained, grey coloured or speckled appearance. Coals.

3,470 to 3,550 — Shales, dark grey. Siltstones, dark grey and grey. Sandstones, very fine to coarse grained; including grey and speckled sandstones with dark coloured chert grains. Coals. Some clay ironstone.

3,550 to 3,630 — Sandstones, medium to very coarse grained. Grits and conglomeratic sandstones; fragments of chert granules and pebbles, light and dark coloured. Minor shales and siltstones in upper part. Coals in upper part.

3,630 to 3,640 — Sandstones, coarse grained, speckled; fragments of chert granules. Sandstones, very fine to fine grained. Minor quartzites, very fine to fine grained, from one thin bed. Coal (? cavings).

3,640 to 3,710 — Sandstones, medium to very coarse grained, speckled; with grits and conglomeratic layers; fragments of chert granules and pebbles, light and dark coloured.

3,715 — Brenot Formation

3,710 to 4,080 — Sandstones mostly very fine and fine grained, including: argillaceous and silty sandstones; grey and light coloured sandstones; speckled sandstones, with dark coloured chert grains and medium grained parts. (These sandstones occur in interbeds with decreasing frequency downward.) Siltstones. Shales and carbonaceous shales. Coals. (See Section 2 and Figure 4 for a detailed description of this interval.)

Beaudette Group

4,074 — Monach Formation

4,080 to 4,210 — Quartzites, uniformly fine grained and well sorted. Sandstones and quartzitic sandstones, clean, light grey to grey coloured. Quartzites and clean sandstones decrease in lower part, and give way to siltstones with very fine grained sandstones, and few shales. (Some coals and carbonaceous shales, present in the upper part of this interval, probably represent cavings.)

4,210 — Beattie Peaks Formation

4,210 to 4,290 — Siltstones, grey, brownish, mostly clean. Sandstones, very fine grained, grey, compact. Lesser shales, dark grey, and silty shales.

4,283 — Monteith Formation

4,290 to 4,460 — Quartzites and quartzitic sandstones, medium to very coarse grained; much authigenic quartz in secondary growth on clastic grains. Lesser sandstones, grey and brownish coloured. Few shales, dark grey and black, and siltstones.

4,460 to 4,580	Quartzites and quartzitic sandstones, as above. Quartzites, and clean sandstones, very fine grained. Shales, siltstones, and argillaceous sandstones, increasing downward.
4,580 to 4,670	Sandstones, siltstones, and shales, with few quartzites. Sandstones predominate and include the following types: clean sandstones, very fine grained; grey and brownish sandstones, very fine to medium grained, and argillaceous to varying degrees; few sandstones, speckled with dark coloured chert grains. Siltstones relatively abundant, and include: grey quartzitic siltstones, in association with the clean, very fine grained sandstones; grey to dark grey, and brownish coloured siltstones, usually argillaceous.
4,670 to 4,720	Shales, dark grey and black; silty shales. Siltstones, grey and quartzitic; siltstones dark and brownish grey. Some argillaceous sandstones. Few, very fine grained quartzites.
4,720 to 4,880	Sandstones, fine and medium grained, grey and dark coloured, and argillaceous. Lesser shales, dark grey, and black. Few siltstones. Quartzitic and clean sandstones in minor amounts.
4,880 to 5,250	Quartzites, and quartzitic sandstones, fine to coarse grained. Sandstones, dark grey and brownish grey, medium grained mostly; present in lesser amounts. Siltstones, grey and dark brownish grey. Shales, black and dark grey.

Fernie Group

5,250 Transition Beds

5,250 to 5,328	Sandstones, very fine to fine grained. Siltstones. Shales, dark grey. Few quartzitic sandstones.

5,328 "Fernie Shales"

5,328 to 5,440	Shales, black to dark grey, mostly. Few siltstones, dark or brownish grey. Very few thin sandstones, very fine to fine grained.

Cored Intervals

Interval (Feet)	Recovery (Feet)	Recovery (Inches)	Description
			Dresser Formation
3,368 to 3,370	0	6(?)	Sandstone, light grey, speckled; fine to medium grained, with light and dark coloured chert grains.
			Dip: 33 degrees.
			Brenot Formation
4,065 to 4,067	1	1	Sandstone, very fine grained, with interlaminated siltstones and shales.

Interval (Feet)	Recovery (Feet)	Recovery (Inches)	Description
			Dip: 5 degrees to 10 degrees.
4,079 to 4,081	0	8	Sandstone, fine grained, with thin partings of carbonaceous shale. (? Depth ? Monach Formation)
			Dip: about 10 degrees.
			Monteith Formation
4,992 to 5,017	10	8	Sandstone, grey, fine to medium grained; with thin shale and siltstone partings. Passing to cleaner and more uniform sandstone with few clay galls and shale partings, in lower half.
	1	3	Shale, dark grey to black, with laminae and thin partings of siltstone and very fine grained sandstone.
			Dip: average of 10 degrees.

Section No. 2

French Petroleum Company - Richfield, Brenot Creek No. 1 Well:

Interval 3,710 to 4,074 Feet

Interval (Feet)	Description of Drill Cuttings
	Type Section of the Brenot Formation 3,715 to 4,074 Feet
3,710 to 3,730	Shales and silty shales, dark grey; black, carbonaceous shales. Siltstones, dark grey. Sandstones, very fine to fine grained, argillaceous; few sandstones, medium grained, speckled with dark coloured chert grains. Coal in fresh cuttings.
3,730 to 3,760	Siltstones, dark grey. Sandstones, very fine grained, argillaceous; sandstones, fine grained, speckled with light and dark coloured chert grains. Lesser shales. Coals.
3,760 to 3,800	Shales, dark grey; silty shales; carbonaceous shales. Lesser siltstones, dark grey. Some sandstones, very fine to fine grained, argillaceous. Coals.
3,800 to 3,840	Sandstones, dark grey, very fine to fine grained, argillaceous; sandstones, mostly fine grained, speckled with dark coloured chert grains. Siltstones, dark grey. Lesser shales, and silty shales, dark grey; carbonaceous shales. Coals.
3,840 to 3,870	Sandstones, grey, very fine to fine grained. Siltstones, grey to dark grey. Shales and silty shales; carbonaceous shales. Coals.

Interval (Feet)	Description of Drill Cuttings
3,870 to 3,890	Sandstones grey, very fine to fine grained, and argillaceous sandstones; sandstones, mostly fine grained, speckled with dark coloured chert grains. Siltstones, grey to dark grey. Shales and silty shales.
3,890 to 3,920	Siltstones, grey to dark grey. Shales and silty shales for the most part. Lesser sandstones, grey, very fine to fine grained, commonly argillaceous.
3,920 to 4,010	Sandstones, grey, very fine to fine grained, commonly argillaceous. Minor sandstones, fine grained, speckled. Siltstones, grey to dark grey. Shales and silty shales, dark grey; carbonaceous shales, black. Coal in fresh cuttings.
4,010 to 4,040	Sandstones, grey, very fine to fine grained, mostly argillaceous. Sandstones, fine grained mostly, speckled with dark coloured chert grains. Siltstones, grey to dark grey. Shales and silty shales, dark grey.
4,040 to 4,080	Sandstones, grey, very fine to fine grained, mostly argillaceous. Siltstones, grey to dark grey. Shales and silty shales, dark grey; carbonaceous shales, black. Coal, quite abundant in fresh cuttings.

(Base: 4,074 feet.)

GRANT KNOB, PEACE RIVER CANYON

The section at Grant Knob is exposed in the west limb of the Portage Mountain anticline (Figure 5). It is accessible by trail from the Gething mine which is 9 miles southwest of Hudson Hope. Exposures are discontinuous, and the section is difficult to work on account of deep gullying on the south face of Grant Knob. Mapping on this face supplemented the record of the Sections, Nos. 3, 4, and 5. Cores taken by B.C. and B.B. Power Consultants Limited also gave an additional subsurface section.

The Beaudette Group contains the Monteith Formation and overlying beds referred to the Beattie Peaks Formation. The latter beds are traced to a contact with the Crassier Group. The sandstones and quartzites of the Monach Formation are absent at this locality. The Crassier Group are coal measures and include the Brenot, Dresser, and Gething Formations. The Gething Formation outcrops along the Peace River Canyon, upstream from Grant Knob to the locality of Section 7 near the entry of the Canyon.

The Monteith Formation contains quartzites, quartzitic sandstones, and grits, brownish weathering sandstones, and argillaceous sandstones, with lesser shales and siltstones. Quartzites and quartzitic sandstones form thick beds, and are distributed throughout the formation, being interbedded with sandstones and shales. Sandstones and quartzite beds, overlying shales, contain clay galls and shale fragments near the base. Load casts, flow trails, and impress structures also mark their basal contact with shales. Current bedding is frequent in the quartzites and grits, and in places is marked by gradations and alterations of fine and coarse layers, one-quarter to 1 inch thick. Sorting is variable in the arenites, even in single beds. Sandstones and fine quartzites are both plane and current bedded, and sometimes ripple marked. Shales form a minor part of the formation and include: dark grey shales with silty and sandy partings, and

laminae; and silty brownish grey shales, thinly interbedded with sandstones. Fine, carbonized plant debris is common in the shales. The assemblage of sediments is distinctive, and characteristic of the Monteith Formation. Its development at Grant Knob differs from that of the type area in the following ways: it has a greater proportion of quartzites and quartzitic sandstones; the quartzites are distributed throughout the formation and occur in its lower part. The Monteith Formation lies in the core of the Portage Mountain anticline, and about 800 feet of beds outcrop here. Exposures from the upper part of this interval are described in Section 3. The formation is +1,010 feet thick, according to the results of the mapping, and the record of the cores. The base of the formation is concealed.

The interval between the Monteith Formation and the Crassier Group contains 330 feet of beds, which are placed in the Beattie Peaks Formation. The lower part of

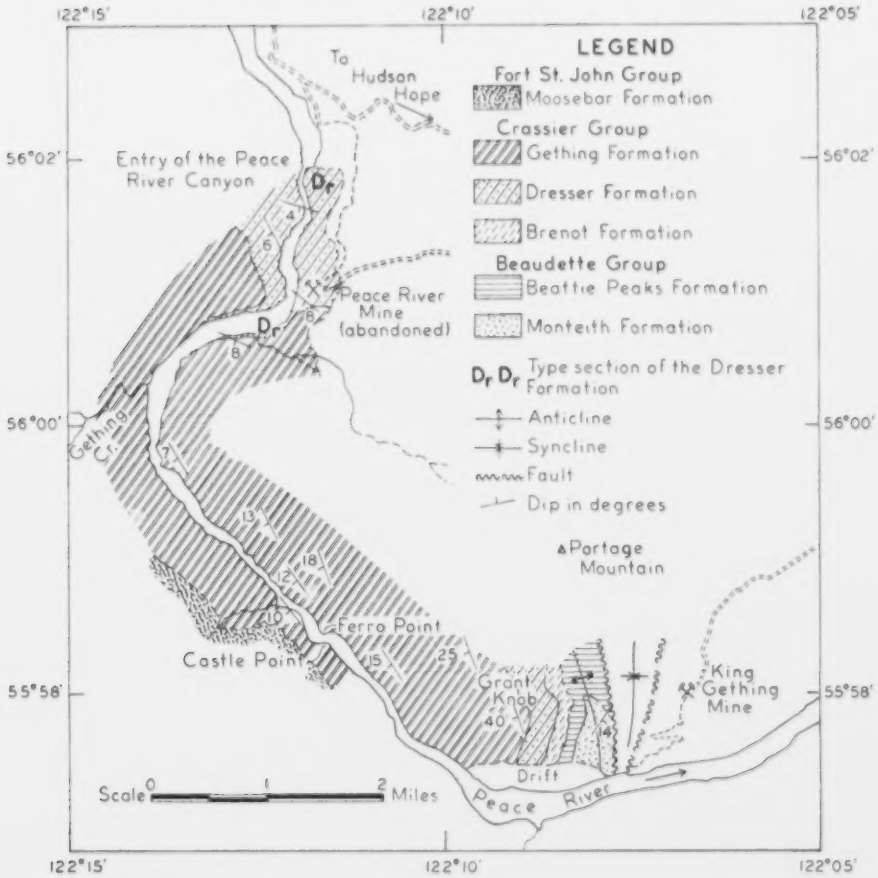


Figure 5. The Beaudette and Crassier Groups in the Peace River Canyon.

this interval is concealed. The upper 120 feet of beds are well exposed, and consist of dark grey shales, siltstones, and very fine to fine grained sandstones. They occur in cyclic sequences 2 to 6 feet thick. The sandstones increase in proportion upward in the section, where they become predominant. These beds resemble the Beattie Peaks Formation in its western exposures, in the details of lithology. The sandstones are thin bedded and have ripple marks of wide span. They contain partings and laminae of black shale and dark grey shales, which are marked by organic ("worm") imprints, trails, and burrowings. Thin flattened clay galls are present in the sandstones. The cyclic distribution of shales, siltstones, and sandstones is uncharacteristic of the Beattie Peaks Formation in the western Foothills.

Exposures of the Brenot Formation reveal mostly sandstone beds; a few are clear enough to show its full character. These consist of coal measures with cyclic sedimentation. The cyclothems contain, in order: fine grained sandstones; silty and sandy mudstones and carbonaceous mudstones (the seat earths); coals, black, carbonaceous, fissile shales with plant debris (roof shales), passing upward to dark grey mudstones and shales; mudstones and shales with siltstone and sandstone layers. The cyclothems are thin, usually 2 to 8 feet, and several are incomplete, lacking coals, seat earths, and roof shales. Plant debris, coalified remains, and imprints of woody material are abundant in these beds. Mud cracks occur in some places where siltstones and sandstones overlie shales. The formation includes some thicker beds of sandstones, which are mostly fine to medium grained, often argillaceous and containing scattered clay galls and plant debris. These sandstones weather in flaggy beds. Current bedding of short sweep, and close set ripple marking is frequent. Similar sandstones occur near the base of the formation. These have many layers of clay galls, and shale and mudstone phenoclasts of thick lensiform and subangular shapes. The lowest sandstone bed rests on a thin carbonaceous shale, with a wave cut base. This shale follows a coal seam of 1 inch. It is the lowest coal seam observed in the sequence, and is taken as the base of the Brenot Formation. The subjacent sandstone has a modified and unlayered texture in its upper part and contains carbonized traces of branching roots. These sandstones of the lower part occupy an incompletely exposed interval 70 feet thick. They are absent from the drilled section of the Brenot Creek No. 1 well, and their distribution seems complementary to the Monach Formation in this area. The sandstones of this lower interval accumulated in a paralic environment. They may represent infilling of a topographic depression at the onset of non-marine deposition of the Crassier Group. It is possible to regard them as remanent deposits intermediate in age to the Brenot Formation and the beds of the Beaudette Group, or alternatively as a local non-marine facies in part contemporary with the Monach Formation. The evidence is insufficient to decide on these views. This lower interval of 70 feet is presently assigned to the Brenot Formation. Accordingly, the thickness of the Brenot Formation at Grant Knob is given as 485 feet.

The Dresser Formation contains medium to very coarse grained sandstones, conglomeratic sandstones and grits, and a few beds of conglomerate; they form prominent ribbed outcrops on the hillside. Some intervals between these beds are exposed in the lower slopes of Grant Knob and show coal measure sequences. Section No. 5 is a detailed record of one such exposure. At Grant Knob, 710 feet of beds have been included in the Dresser Formation.

Very little of the Gething Formation can be seen at Grant Knob, but it is well exposed further upstream in the Canyon, where sections were recorded by McLearn (1923). Parts of the formation outcropping along this reach have been diamond drilled at Castle and Ferro Points. A description of one of the cores from this area, Section 6,

illustrates the character of the formation.

The Gething Formation includes the following sediments: dark grey shales and mudstone; siltstones; sandstones; sandy and silty mudstones with plant debris and coalified wood fragments and "rootlets"; soft, grey mudstones with listric surfaces; coals; fissile, black, carbonaceous shales with plant debris. Clay ironstone banding is also found. The sediments were deposited in cyclic order, in the sequence listed above. Cyclothems tend to be complete and are contained in intervals of 5 to 25 feet, usually. Coal seams may run to a thickness of 5 feet (see also McLearn; McLearn and Kindle, 1950, p. 154). Sandstones are mostly fine to very fine grained, thin bedded, and ripple marked; they form beds up to 15 feet thick.

Sandstones of coarser grain, some of them with conglomeratic parts, are found in the lower third of the Gething Formation, from Ferro Point to the abandoned Peace River mine. There appears to be four beds of these sandstones, the Heron Creek, Canyon, Galloway, and Cust Island sandstone members of McLearn and Irish (1944, p. 8). They are dispersed throughout this coal measure sequence, and are included in the Gething Formation, according to definitions already stated. (The above stratigraphic names are for local use, and apply to the Peace River Canyon upstream from Gething Creek). Sandstones of this type in the Crassier Group show much lateral change and are not found to be extensive; for example, McLearn and Irish noted the Canyon sandstone member passed to fine sandstone and siltstone, within a distance of less than one-half mile along the wall of the Peace River Canyon.

The Gething Formation is of the order 1,050 to 1,300 feet thick in the Canyon, the base being drawn here, on the top of the Larry sandstone (named by McLearn and Irish, 1944). A few fossils obtained from cores and outcrop in this area included:

Athrotaxites berryi Bell
Fragments, probably Podozamites lanceolatus
Possibly Podozamites lanceolatus
Probably Podozamites lanceolatus and
Pityophyllum cf. P. nordenskiöldi

Fossil dinosaur tracks of the Gething Formation in the Peace River Canyon (Grant Flat to Ferro Point) are known from McLearn's discovery (1923), and the following study by Sternberg (1932). Further upstream, much of the Gething Formation is burned, and ground fires are still active near Ferro Point. These burned and reddened beds, not previously reported in geological literature, were examined by the writer (1959). Mathews (1947, p. 23) has also noted partly burned coal seams and the associated red beds at several localities in the Carbon Creek Valley.

Section No. 3

The Section at Grant Knob, Peace River Canyon

Thickness (Feet)	Description	
	Crassier Group	
	Dresser Formation	710 feet
710.0	Coal measures, with coarse speckled sandstones and grits; few beds of conglomerate with chert and fewer quartzite pebbles (maximum diameter about 1 inch). Including fine and medium grained grey sandstones, silt-	

Thickness (Feet)	Description
	stones, shales, and mudstones, carbonaceous shales, and few thin coals, where observed. (See also detailed description of Section 5.)
	Flora: Elatides curvifolia Bell Elatides splendida Bell Pterophyllum plicatum Bell ? Pterophyllum rectangulare Bell
	(From 110 feet above the base of the formation.)
	Brenot Formation 484.9 feet
182.0	Concealed. (A mappable contact between the Dresser and Brenot Formations is found on the higher slopes.)
32.0	Thin, interbedded shales, mudstones, carbonaceous shales, siltstones, and sandstones. Thin coals. (See also detailed description of Section 4.)
	Flora: Pityophyllum cf. P. nordenskiöldi (Heer) Kryshtofovich Unidentified conifer Drifted fragments of wood, unidentifiable
60.0	Concealed.
25.0	Sandstones, fine and medium grained; thin platy bedded, and rough bedded with shale partings; containing coalified plant debris. Some concealed intervals.
15.0	Sandstone, light grey, speckled by dark coloured chert grains, medium grained with some coarse grained parts; thick crude bedded.
75.0	Concealed.
14.0	Sandstone, speckled, fine and medium grained; ripple marked. Sandstones with thin interbedded shales and shale partings.
0.5	Shale, black, with partings of sandstone containing coalified plant debris and woody fragments.
12.0	Sandstones, mostly fine grained; clean, light coloured, speckled, coarse and medium grained sandstones in lower part, passing to fine grained sandstones, and argillaceous sandstones in upper part; current bedded, with crude sheeting in weathered exposures. Conglomeratic base, with phenoclasts of shale, overlying wave-cut surface--relief 4 to 6 inches.
4.5	Sandstones, grey, fine and medium grained, with thin interbeds and partings of shales and siltstones; containing layers of flat clay galls and coalified plant debris.
30.0	Concealed mostly, but few exposures of interbedded dark grey shales and mudstones, carbonaceous shales, siltstones, and fewer sandstones, fine grained, ripple marked, and containing coalified plant debris.
23.0	Sandstones, with lesser siltstones and shales; some concealed parts. Sandstones, fine and medium grained, few coarse grained sandstones; rough bedded, and thin flaggy, current bedded; argillaceous and containing fine plant debris, and layers of lensiform shale and mudstone phenoclasts,

Thickness (Feet)	Description
	one-quarter inch to 1 inch in diameter. Sandstones overlying shales and siltstones have scoured contacts at their base. Thin interbedded shales, dark grey and brownish grey, carbonaceous shales, and shales with siltstones.
11.0	Sandstone, speckled by dark coloured chert grains; coarse to fine grained; fine and course, coalified plant debris common; conglomeratic layers, with shale and mudstone phenoclasts, one-quarter to 1 inch diameter, and with few pebbles of clay ironstone.
0.5	Sandstone, speckled and rust flecked, medium grained, containing coarse coalified plant debris. Wave-cut and scoured base.
0.3	Shale, black, carbonaceous, fissile; little plant debris.
0.1	Coal, with thin shale and siltstone partings; deeply weathered.
	Beaudette Group
	Beattie Peaks Formation 330.8 feet
0.5	Sandstone, very fine to fine grained, silty and argillaceous; unbedded, or rough bedded; with coalified plant remains, and roots; passing to
2.8	Sandstone, fine grained, silty and argillaceous; thin bedded.
2.0	Sandstone, very fine grained, thin bedded; partings and laminae of silt and black shale.
0.9	Siltstone, dark grey and silty shale, with interlaminated dark grey shales.
5.5	Sandstone, very fine to fine grained; small scale current bedding; ripple marked base.
0.3	Siltstone, and sandstones, dark grey, with black shale partings.
0.3	Sandstone, fine grained.
0.5	Shales, black and dark grey with sandy and silty partings; impressions of plant debris on shale.
30.0	Sandstones and siltsrones, with lesser shales. Simple cyclic sedimentation of fine to coarse clastics upward, in asymmetric sequences, shale-siltstone-sandstone, 2 to 6 feet thick. Shales, black to dark grey, in beds 3 to 9 inches thick, passing upward to siltstones and sandstones with interlaminated shales. Sandstones very fine to fine grained; thin plane bedded, or with wide ripple marking. Sandstones end with clean contact, or thin silty gradation against overlying shale. Flat clay galls in upper part of sandstone beds. "Worm" burrowings and trails frequent in shales with siltstone and sandstone layers. Black mudstone patinas on surfaces of ripple marked and plane bedded sandstones and siltstones.
65.0	Interbedded sandstones, very fine to fine grained, siltstones, and shales, similar to overlying beds. Few concealed parts.
40.0	Concealed.
6.5	Sandstone, very fine to fine grained; brownish weathering; thin, platy bedded with thin shale partings, and interlaminated siltstones in the lower part.
3.5	Thin interbeds, one-quarter inch to 4 inches, of black shale, dark grey siltstone, and very fine-grained sandstone containing shale partings.

Thickness (Feet)	Description
3.0	Sandstone, very fine to fine grained, thin bedded; with shale laminae and partings.
170.0	Concealed.
	Monteith Formation +583.0 feet
23.0	Quartzites and quartzitic sandstones, coarse and medium grained; few thin interbeds of siltstones with shales, and shale partings, and few layers of clay galls. Dark grey, argillaceous, silty sandstone, with shale and mudstone inclusions, and clay galls in the lowermost 6 inches.
32.0	Sandstones, dark grey, very fine to fine grained; sandstones, silty and argillaceous; quartzitic sandstones, grey. Some thin interbeds of black and dark grey shales, silty shales, and siltstones.
63.0	Mostly concealed. Some exposures of quartiztes, quartzitic sandstones, and dark grey sandstones, with shale partings and inclusions; and dark grey siltstones with shales.
15.0	Sandstone, brownish weathering, speckled, rust flecked, medium grained; argillaceous.
40.0	Concealed parts. Sandstones, brownish weathering, fine to medium grained, argillaceous; quartzitic sandstones, and grey sandstones, very fine to fine grained. Dark grey siltstones, and siltstones with shales, and lesser black shales in interbeds. Fine coalified plant debris, "worm" markings and trails, in siltstones and shales.
60.0	Quartzites, and grey quartzitic sandstones, very fine to fine grained; thin interbedded siltstones and shales, dark grey.
100.0	Quartzites, very fine to fine grained, of uniform appearance, with few interbeds of siltstones. In the lower part, passing downward to quartzites, fine to coarse grained, with quartzitic grits, and a few thin interbeds of siltstones and black shales with plant debris.
250.0	Partly concealed. Quartzites fine to very coarse grained, with quartzitic grits, in beds 5 to 20 feet thick. Some thin interbeds of dark grey, silty and sandy shales, and shales.
	Lower part locally concealed.

Section No. 4

Detail of Part of the Brenot Formation, Grant Knob:

Interval 270 to 300 Feet Above the Base of the Formation

Thickness (Feet	Inches)	Description
8	10	Thin interbedded sandstones and shales.
		Flora: Pityophyllum cf. P. nordenskiöldi (Heer) Kryshtofovich Unidentified conifer Drifted fragments of wood, unidentifiable

Thickness (Feet)	Thickness (Inches)	Description
1	10	Shale, dark grey, rubbly, passing downward to--
0	2	Shale, black, fissile, carbonaceous, with fine coalified plant debris.
1	2	Sandstone, fine to medium grained, thin bedded, with shale and siltstone partings, traces of rootlets.
1	1	Shale, dark grey, rubbly, with mud cracked layers; passing to carbonaceous fissile shales containing fine coalified plant debris, at the base.
0	4	Coal, deeply weathered.
0	3	Shale, black, fissile, with fine plant debris.
4	0	Concealed; shale rubble.
6	0	Sandstone, fine to medium grained; thin bedded; with thin interbeds and partings of shale. Wave-cut base, with organic markings and casts.
2	6	Shale, dark grey.
0	3	Mudstone, brownish grey, silty and sandy; tough, unbedded texture. Organic trails and casts at base.
0	2	Coal.
0	10	Siltstone, sandy, argillaceous, unbedded, coalified plant debris and rootlets at top; passing to dark grey mudstone in lower part.
0	2	Siltstone, argillaceous, unbedded; with coalified root traces.
0	6	Shale, dark grey, rubbly.
0	6	Siltstone, brownish grey, argillaceous; with plant debris; passing to--
3	6	Sandstone, fine to medium grained; thin flaggy and rough bedded.

Section No. 5

Detail of Part of the Dresser Formation, Grant Knob:

Interval 100 to 121 Feet (±5 Feet) Above the Base of the Formation

Thickness (Feet)	Thickness (Inches)	Description
7	6	Sandstone, medium to very coarse grained, with conglomeratic layers; pebbles of chert, few pebbles of quartzite.
7	0	Sandstones fine to very coarse grained, with some phenoclasts of shale, and clay ironstone pebbles.
1	2	Sandstone, grey, fine grained, current bedded.
0	1	Shale, black, fissile, carbonaceous; much fine plant debris.
		Thin, irregular coal parting.
0	5	Mudstone, dark grey, rubbly, passing upward to carbonaceous shale.
2	4	Siltstone, brownish grey, thin bedded, passing to unbedded argillaceous, sandy siltstone, and silty mudstone, in the upper part.

Thickness (Feet	Inches)	Description
0	4	Shale, dark grey, fissile, passing upward to dark grey, rubbly mudstone.
		Coal parting, one-half inch.
0	2	Shale, dark grey, rotted.
1	9	Siltstone, brownish grey, argillaceous; much plant debris.

Flora: Elatides curvifolia Bell
Elatides splendida Bell
Pterophyllum plicatum Bell
? Pterophyllum rectangulare Bell

Section No. 6

Description of a Cored Section of the Gething Formation

Diamond-Drill Hole 2-6

Locality: North bank of the Peace River Canyon in the area of Ferro Point: 7,110 feet south and 164,830 feet east, in co-ordinates, from an origin at latitude 56 degrees 00 minutes north, longitude 123 degrees 00 minutes west. Also, 780 feet on a bearing north 43 degrees west, from Castle Point.
Elevation: 1,910 feet
Inclination: Vertical
Interval: 195 to 383 feet

The dip of strata is 11 degrees to 17 degrees, and the computed thickness of the section is 182 feet. The top of the described section lies 750 (±25) feet below the Moosebar-Gething boundary.

Interval (Feet)	Recovery (Feet	Inches)	Description
195 to 208	1	2	Shale, black fissile.
	0	6	Coal, canneloid.
	0	4	Shale, black, fissile.
	0	1	Coal, dull, banded.
	3	3	Shale, in broken core.
	2	0	Sandstone, very fine to fine grained, with interlaminated siltstones and shales; passing to--
	0	6	Shale, silty.
	1	8	Coal, bright, banded.
	1	0	Siltstone, argillaceous, rough bedded; plant debris.
	1	1	Shale, dark grey; plant debris.
208 to 228	4	4	Sandstone, fine grained; passing to--
	12	3	Sandstone, very fine to fine grained; with interlaminated and thin interbedded siltstones and shales.

Interval (Feet)	Recovery (Feet	Inches)	Description
	3	0	Shale, dark grey.
228 to 245	0	6	Shale, dark grey passing to fissile, black carbonaceous shale in lower part.
	2	7	Coal, banded.
	1	2	Mudstone, dark brownish grey; with silty and sandy partings; coarse plant debris.
	0	2	Coal, banded.
	0	6	Mudstone, grey, silty; coarse plant debris.
	2	7	Shale, dark grey; with siltstone laminae.
	9	6	Sandstones, very fine to fine grained; with thin interbeds of shales and siltstones. Passing to shales with siltstones in lower part.
245 to 267	11	9	Shale, dark grey with few thin interbeds, and laminae of sandstone and siltstone.
	3	8	Sandstone, medium grained; speckled.
	5	4	Sandstone, very fine to fine grained, grey; with thin interbeds and laminae of siltstones and shales; layers of plant debris.
267 to 288	0	7	Mudstone; passing to--
	2	7	Siltstone and very fine grained sandstone, with shale partings.
	7	0	Shale, dark grey, with laminae of siltstone and sandstone.
	0	2	Shale, dark grey to black.
	0	1	Coal.
	0	4	Rubble.
	0	3	Shale, dark grey.
	8	6	Sandstone, very fine to fine grained, and siltstones, with thin shale interbeds; increase of shale in lower part and passing to--
288 to 305	2	3	Shale, dark grey.
	11	9	Sandstone, very fine to fine grained, with thin interbeds of siltstones and shale; increase of shale in lower part, and passing to--
	3	0	Shale, dark grey.
305 to 328	0	4	Shale, black, fissile, carbonaceous.
	0	3	Coal.
	11	0	Sandstone, fine grained, with laminae of plant debris, and thin interbeds of shale. Passing down to shale in lower part.
	0	3	Shale, black, fissile, with coaly partings.
	1	2	Coal.
	0	8	Siltstone, argillaceous, with sandy partings; unbedded; coalified plant debris, and coaly partings.
	10	0	Sandstone, very fine to fine grained; with thin interbeds of siltstone and shale.
328 to 347	0	4	Shale, dark grey, fissile, carbonaceous.

Interval (Feet)	Recovery (Feet	Inches)	Description
	0	9	Mudstones, grey, soft, with plant debris and coaly partings.
	0	4	Coal.
	0	5	Mudstone, silty, blackish, unbedded; plant debris, and coaly partings.
	0	7	Shale with sandstone; passing to--
	2	9	Sandstone, fine grained.
	3	6	Interbedded sandstones, siltstones, and shale; passing to shale in lower part.
	0	4	Coal: rubble in broken core.
	0	8	Mudstone, soft; plant debris.
	2	6	Shale, dark grey, few thin interbeds and laminae of siltstone and sandstone.
	4	9	Thinly interbedded sandstones, siltstones, and shales.
347 to 363	6	0	Shale, dark grey; some thin interbeds of sandstone, very fine and fine grained.
	0	6	Shale, black, carbonaceous.
	0	2	Coal.
	1	2	Mudstone, grey, soft; plant debris.
	2	6	Sandstone, fine grained.
	1	3	Mudstone, grey, soft; plant debris.
	1	0	Coal: banded.
	0	2	Sandstone, argillaceous; plant debris and coaly partings.
	0	4	Mudstone, dark grey.
	3	0	Core missing.
363 to 383	5	3	Mudstone, dark grey, passing downward to shales with thin laminae and interbeds of sandstone and siltstone.
	1	6	Mudstone, dark grey to black.
	2	6	Sandstone, fine grained; few shale partings.
	10	3	Mudstones and shales, dark grey; few partings, and thin interbeds of siltstone, and very fine grained sandstone.

ENTRY OF THE PEACE RIVER CANYON: DRESSER FORMATION

The main dam across the Peace River Canyon is now under construction, 1 mile downstream from the entry of the Canyon at the Portage Mountain Damsite (Plates II and III). Diamond drilling to test the foundations of the site provided a composite section of the Dresser Formation (Section 7; Figure 5). The section depends on the correlation of coal measure cycles in nineteen drill holes, in an area 8,000 by 3,000 feet, together with observations on outcrops along the Canyon.

In the Dresser Formation, the coal measure sequences include, shales, carbonaceous shales, mudstones, coals, siltstones, and fine to medium grained sandstones. They are separated by thick beds of coarser grained sandstones and grits with conglomerate. These beds compose about half the formation. The coarser sandstones and grits with conglomerate are current bedded, with well marked fore and bottom sets; they show slump bedding in some cores. Individual beds vary in thickness; some are impersistent, and parts of others pass laterally to finer grained sandstones, and sandstones with silt-

stones and shales. Several beds of the coarser sandstones and grits truncate the underlying coal sequences, so forming washouts. These washouts appear to be of minor order, except for one showing the removal of 37 feet of strata. Coal seams (reported as core recovery) are thin, the majority less than 12 inches. The Murray seam of 5 feet is an exception. The formation contains forty seams, including twelve closely spaced pairs, at this locality. In places, coal seams are missing due to penecontemporaneous erosion, and due to restricted area of deposition. Splitting of coal seams is quite common. The thickness assigned to the formation is 770 feet, but this may need to be increased to 810 feet, at some points, in order to include erratic developments of coarse sandstones and grits with conglomerate.

Section No. 7

Description of Cored Section of the Dresser Formation

Type Locality: West end of the Peace River Canyon, 2 miles northeast of the confluence of Gething Creek and the Peace River. The described section was cored in three diamond-drill holes. The diamond-drill holes are located by a co-ordinate system in feet, from an origin at latitude 56 degrees 00 minutes north, longitude 123 degrees 00 minutes west.

Diamond-drill core intervals are reported to the nearest foot in most cases. Recovery is measured to the nearest foot in thicker beds. Thickness of coal seams is reported as recovery in core. Missing core, less than 2 feet in amount, is disregarded. Dip of strata is 10 degrees (average). Drill holes are vertical.

The vertical interval of Dresser Formation reported and correlated is 782 feet; the computed thickness is 770 feet.

Diamond-Drill Hole No. 17

Co-ordinates: 6,178 north and 164,655 east
Elevation: 2,139 feet
Inclination: vertical

Interval (Feet)	Recovery (Feet)	Recovery (Inches)	Description
0 to 14	14	0	Overburden.
			Gething Formation
14 to 16½	2	6	Sandstone, grey, fine grained, with thin interbeds of siltstone.
			Dresser Formation: 234 feet
16½ to 37	12	4	Sandstone, very coarse to medium grained; speckled appearance due to grains of light and dark grey chert.

Interval (Feet)	Recovery (Feet	Inches)	Description
	1	2	Conglomeratic grit; with pebbles of vari-coloured chert, and coarse, carbonized plant debris.
	4	0	Sandstone, fine grained; small scale current bedding, ripple marking.
	1	6	Shale, dark grey, silty, with thin sandstone interbeds in lower part.
	1	6	Sandstone, medium to coarse grained, speckled.
37 to 60	19	0	Sandstone, medium to coarse grained, speckled.
	0	2	Shale, black.
	2	3	Sandstone, grey, fine and very fine grained; with inter-laminated and thin interbedded siltstones and shales.
	1	10	Shale, dark grey.
			Coal (parting).
60 to 74	13	0	Shale, dark grey; with few interbeds of siltstone, and fine to very fine grained sandstone.
	0	4	Shale, black, carbonaceous.
	0	3	Coal.
	0	2	Sandstone, fine grained.
	0	1	Coal.
	0	4	Shale, grey; with plant debris.
74 to 85	3	0	Shale, dark grey.
	8	0	Sandstone, medium to coarse grained; speckled--grains of light and dark grey chert; with thin interbedded grits, and fine grained, speckled sandstones.
85 to 110	25	0	Sandstone, medium and coarse grained, speckled with grains of light and dark coloured cherts; with thin inter-beds of grits and fine grained, speckled sandstones.
110 to 118	2	6	Sandstone, medium grained, speckled.
	3	4	Shale, dark grey with carbonized plant debris; and few thin coaly laminae.
	2	0	Core missing.
118 to 152	33	0	Shale, dark grey, and silty shale grey; with interlamina-ted and thin interbedded fine to very fine grained sand-stones, and siltstones; including 2 inches of carbonaceous shale at base.
152 to 156	0	2	Coal, dull, thin banded.
	1	4	Shales, dark grey and black; plant debris.
	0	1	Coal.
	0	7	Shales, black, carbonaceous; plant debris.
	1	6	Coal, bright, banded, strong (Murray seam).
159 (?) to 163			Core missing (3 to 5 feet ?).
	1	10	Coal, bright, banded, strong (Murray seam).
	0	6	Shale, grey, passing to silty shale, and siltstone.
163 to 182	9	6	Sandstone, grey, brownish coloured, fine grained, plane and current bedded; with lenses of shale, and few, thin beds of fine to medium grained, speckled sandstones.

Interval (Feet)	Recovery (Feet	Inches)	Description
	11	0	Shale, dark grey, passing downward to shales with interlaminated and thin interbedded fine to very fine grained sandstones.
182 to 206	24	0	Interlaminated and thin interbedded, fine to very fine grained sandstones, and shales.
206 to 227	18	0	Disturbed core, including: dark grey shale; fine grained, grey sandstones; medium to coarse grained, speckled sandstones.
	3	0	Core missing.
227 to 250	20	0	Sandstone, medium to coarse grained, speckled.
	1	3	Coal.*

Diamond-Drill Hole No. 45

Co-ordinates: 7,606 north and 165,424 east
Elevation: 2,081 feet
Inclination: vertical

Interval (Feet)	Recovery (Feet	Inches)	Description
			Dresser Formation (continued): 294 feet
15 to 40	12	6	Sandstone, medium to coarse grained, speckled; cross-bedded.
	0	3	Coal (fragments).*
	0	9	Rubble; coal and shale.
	1	2	Shale, black, carbonaceous, with plant debris.
	8	0	Shale, dark grey, with interlaminated siltstones and very fine grained sandstones; few thin interbeds of fine grained, grey sandstones.
40 to 64	7	6	Shale, dark grey.
	0	2	Coal (fragments).
	9	4	Shale, dark grey; passing downward to silty shales with few interbeds of fine grained sandstones.
	7	0	Sandstone, fine grained; speckled with light and dark grey chert grains.
64 to 87	22	0	Sandstone, coarse to medium grained, speckled with light and dark grey chert grains.
87 to 111	6	3	Sandstone, medium grained, speckled.
	7	6	Sandstone, fine to very coarse grained, with conglomeratic layers; pebbles of dark and light grey coloured chert, and minor quartzites to 1 inch diameter.
	0	1	Coal.

*Correlated with top coal seam of 3 inches recovery in diamond-drill hole No. 45.

Interval (Feet)	Recovery (Feet	Inches)	Description
	9	0	Shales, dark grey; with thin interbeds of fine grained, grey sandstone, and medium grained speckled sandstone.
111 to 135	24	6	Sandstone, medium to coarse grained in lower part; speckled.
135 to 160	24	0	Sandstone, fine to very coarse grained, and grits, speckled; thin interbeds of conglomeratic sandstone and grit--pebbles of chert, quartzite, shale, and clay ironstone.
160 to 183	1	9	Sandstone, fine grained, light grey, or partly speckled.
	0	3	Shale, black, carbonaceous.
	0	5	Coal, bright, banded.
	0	3	Shale.
	0	2	Coal (fragments).
	4	3	Shale, dark grey and silty, pyritic shale.
	3	4	Interbedded grey, fine grained sandstones, and dark grey shales.
	12	8	Sandstone, medium to very coarse grained; speckled with light and dark grey chert grains; several thin interbeds of pebbly grit.
183 to 207	24	0	Sandstone, medium to coarse grained; with several interbeds of pebbly grits; pebbles of light and dark grey chert, to 1 inch in diameter.
207 to 232	18	6	Sandstone, medium grained, cross bedded; with few pebbly layers in lower part.
	0	1	Coal.
	6	0	Shale, dark grey; with few laminae and interbeds of siltstone and fine grained sandstone.
232 to 260	23	0	Shale, dark grey; with thin interbedded siltstones, and fine grained grey sandstones.
	3	0	Core missing.
	1	2	Sandstone, very coarse grained, speckled.
260 to 285	21	0	Sandstone, medium to very coarse grained, speckled; cross bedded.
	1	0	Coal, bright, banded.
	2	3	Shales, black and dark grey; plant debris.
285 to 310	2	2	Shale, and silty sandy shales.
	0	2	Coal.
	0	3	Shale.
	0	5	Coal.
	9	3	Shale, dark grey; with carbonaceous shales; plant debris.
	0	2	Coal.
	1	8	Shale, black, carbonaceous; plant debris.
	0	2	Coal.
	8	2	Shale, dark grey, and silty shales.
	0	3	Coal.
	2	3	Shale, dark grey, and silty shales.
310 to 322	5	0	Shale, and silty shale, with few interbeds of fine grained sandstones.

Interval (Feet)	Recovery (Feet)	Recovery (Inches)	Description
	0	2	Coal, dull, thin banded.
	6	4	Interbedded shales, silty shales, and fine grained grey sandstones.
			*Sandstone, fine and medium grained.

Diamond-Drill Hole No. 4

Co-ordinates: 8,410 north and 163,800 east
Elevation: 1,690 feet
Inclination: vertical

Interval (Feet)	Recovery (Feet)	Recovery (Inches)	Description
			Dresser Formation (continued): 254 feet
40 to 48	8	0	*Sandstone, fine grained; with clay gall horizon in middle part; and few interbeds of siltstone.
48 to 67	11	0	Sandstone, fine grained; with thin interbeds of speckled sandstone in lower part.
	8	0	Sandstone, medium grained, speckled; with few horizons of clay galls.
67 to 87	20	0	Sandstone, fine to very coarse grained, speckled; with few layers of clay galls. Lower 5 feet, with layers of chert pebble conglomerate.
87 to 105	18	0	Sandstone, fine to very coarse grained, speckled; with some thin layers of chert pebble conglomerate.
105 to 123	4	3	Sandstone, medium to very coarse grained; with thin interbeds of chert pebble conglomerate.
	13	3	Shales, dark grey and carbonaceous shales with plant debris and coaly laminae.
123 to 144	1	3	Shale, dark grey.
	0	3	Coal, with shale partings.
	6	0	Shales, dark grey; silty and sandy shales.
	12	0	Siltstone, with thin interbeds of fine grained sandstone and shale.
144 to 161	7	0	Sandstone, fine grained, light grey, with few thin shale interbeds.
	10	0	Sandstone, medium to coarse grained, speckled.
161 to 180	19	0	Sandstone, medium to coarse grained, speckled; few layers of clay galls.
180 to 218	38	0	Sandstone, medium to coarse grained, speckled; with few layers of chert pebble conglomerate, and clay galls.

*Correlated with sandstone of the interval 40 to 48 feet, in diamond-drill hole No. 4.

Interval (Feet)	Recovery (Feet)	Recovery (Inches)	Description
218 to 236	16	6	Sandstone, medium to very coarse grained, speckled.
			Coal (parting).
	1	6	Siltstone, dark grey.
236 to 266	23	0	Sandstone, fine to very coarse grained; interbeds of coarse grits.
	4	0	Conglomeratic grit; pebbles of dark and light grey coloured chert.
	2	6	Shale, dark grey and carbonaceous shales.
	0	6	Mudstone, black, carbonaceous, with fine plant debris, and coaly partings.
266 to 297	0	6	Coal.
	1	1	Shale, black, carbonaceous.
	0	3	Coal.
	3	0	Shale, black, carbonaceous, passing to dark grey, silty shale in the middle part. Carbonaceous shale with thin coaly partings at the base.
	0	2	Coal.
	0	6	Coal with shaly partings.
	0	6	Siltstone, sandy, and argillaceous, brownish grey; plant debris and coaly streaks.
	2	6	Shale, dark grey, passing to--
	10	0	Interbedded shales, siltstones, and sandstones, very fine to fine grained; few interbeds of speckled sandstones.
	10	0	Sandstone, medium to very coarse grained; scattered phenoclasts of shale; slump bedding.
			Brenot Formation
	0	2	Coal.
	1	10	Mudstone, with coalified plant debris, passing to shale, dark grey.
	0	3	Shale, black, fissile, carbonaceous, with thin coal laminae.
	0	4	Sandstone, dark grey, fine grained, argillaceous.

RAINBOW ROCKS AND DUNLEVY CREEK

Part of the Bullhead succession can be traced in the area of the Rainbow Rocks. This name alludes to exposures on the north side of the Peace River valley, which show strata in the west limb of the Dunlevy syncline arched in a slight flexure. The Mount Gething-Stott Creek anticline adjoins this structure on the west. Most exposures consist of sandstones and quartzites in benches on the valley side. The formations outcropping in the west limb of the Dunlevy syncline are mapped in Figure 6.

One mile southeast of the Rainbow Rocks, quartzites, grits, and shales of the Monteith Formation occur at the level of the river plain, and at an elevation of 2,000 feet. The overlying interval is drift covered except for a small outcrop of dark, brown-

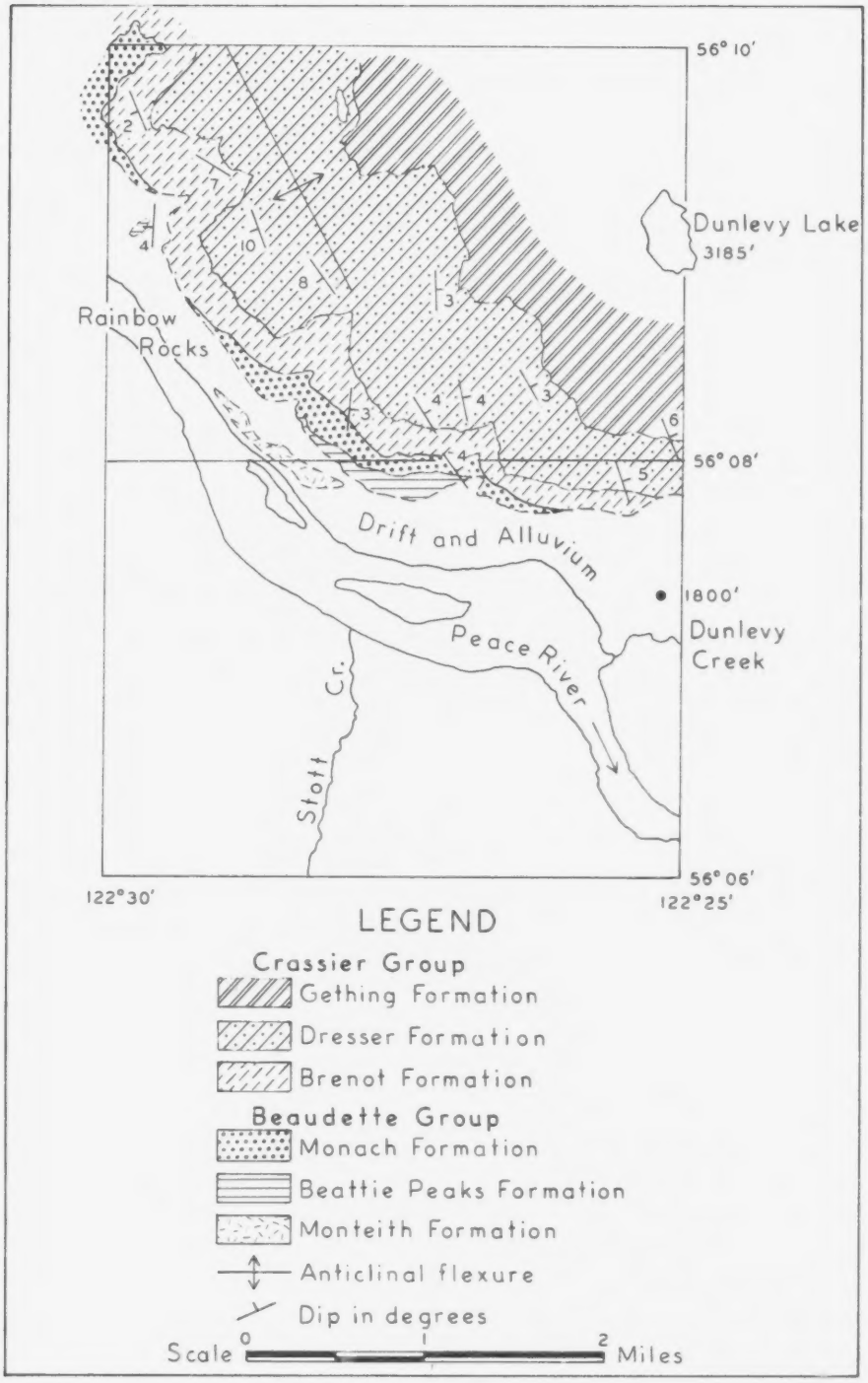


Figure 6. The Beaudette and Crassier Groups at Rainbow Rocks.

ish grey shales, with thin interbeds of siltstones and fine grained sandstones. This interval is referred to the Beattie Peaks Formation. The Monach Formation is continuously exposed in a distinct bench, at elevations between 2,200 and 2,500 feet, and contains buff coloured, fine grained sandstones followed by the quartzites and quartzitic grits of the upper member. About 260 feet of the formation can be seen.

A recessed slope above the Monach quartzites shows thin sandstones and argillaceous sandstones characteristic of the Brenot Formation. Some clear sections, observed in the mapping, reveal dark grey shales and mudstones, carbonaceous shales, and fine to medium grained snadstones, with much coalified plant debris. One thin coal seam was found, about 60 feet above the Monach quartzites.

The Dresser Formation outcrops in the steep, upper walls of the valley. Sandstones and grits form low cliff faces here; little can be seen of the intervals between, other than some shale beds and coal spoil. However, the uppermost 100 feet of the formation is clearly shown along the first tributary, upstream on the east side of Dunlevy Creek. The walls of this tributary creek show cyclic repetitions (2 to 5 feet thick) of shales, siltstones, sandstones, and coals (seams less than 8 inches thick) in one interval between thick beds of coarse grained sandstones.

Section No. 8

First Section Near the Rainbow Rocks

Location: Bearing north 60 degrees west; distance 2 miles from the confluence of Dunlevy Creek and the Peace River.

(Based on measurements by altimeter and range finder.)

Thickness (Feet)	Description
	Crassier Group
	Brenot Formation — 423 feet
13.0	Concealed.
60.0	Interbedded sandstones, fine to medium grained, siltstones, mudstones, and shales, in sequences as noted below.
	Sandstone, grey, thin flaggy bedded, ripple marked.
2 to 8 feet	Siltstone, or shales with siltstones.
	Silty mudstones, with plant debris.
	Shales and mudstones, dark grey.
350.0	Concealed mostly. Some exposures of sandstones, brownish grey, argillaceous; with shale partings and interbedded siltstones; thin and rough bedded, much coalified plant debris.
	Beaudette Group
	Monach Formation — +253 feet
18.0	Quartzite, coarse to very coarse grained, with quartzitic grits.

Thickness (Feet)	Description
40.0	Concealed.
45.0	Quartzites, coarse to very coarse grained, with quartzitic pebbly grits; pebbles of quartzite, very few of chert.
35.0	Partly concealed; exposures of clean sandstones and quartzitic sandstones.
35.0	Sandstones, light coloured, buff weathering, clean; with some quartzitic sandstones.
60.0	Concealed, mostly; few exposures of clean light coloured sandstones weathering in buff colours.
20.0	Sandstones, buff weathering, fine to medium grained.
360.0	Concealed interval, referred to Beattie Peaks Formation. 360 feet
	Monteith Formation +218 feet
20.0	Quartzites, white, mostly coarse grained; some concealed parts.
165.0	Concealed.
22.0	Quartzites, fine to very coarse grained, becoming more fine grained and thin plane bedded upward; with quartzitic grits, thick crude current bedded. Including pebbly, quartzitic grits, with angular "torrential" cross bedding in lower 8 feet.
3.5	Interbeds of black shales, siltstones, and grey, fine grained, quartzitic sandstones.
7.5	Quartzites, and quartzitic sandstones, with some thin interbeds of dark grey shales with siltstone and sandstone partings. Much plant debris, including: Elatides splendida Bell River plain.

Section No. 9

Second Section Near the Rainbow Rocks

Location: Bearing north 45 degrees west; distance 1½ miles from the confluence of Dunlevy Creek and the Peace River.

(Based on measurements by altimeter and range finder.)

Thickness (Feet)	Description
	Crassier Group
	Dresser Formation 879.0 to 929.0 feet
400 to 450	Concealed parts. Sandstones, medium to very coarse grained, grits, with minor amounts of chert pebble conglomerate; fine to medium grained

Thickness (Feet)	Description
	sandstones and argillaceous sandstones; minor siltstones, shales, and carbonaceous shales; coal spoil in places. No detailed measurements. Upper boundary indistinct, locally.
15.0	Sandstones, medium to coarse grained, grits and pebbly grits; speckled appearance due to light and dark coloured chert grains.
7.0	Sandstone, medium to coarse grained, current bedding; passing upward to fine grained sandstone.
2.0	Grit; conglomeratic layers, with pebbles of chert (maximum median diameter about 1 inch), and clay ironstone.
65.0	Concealed.
6.0	Sandstone, brownish grey, fine to medium grained; thin bedded and ripple marked.
65.0	Concealed.
3.0	Grit, conglomeratic, matrix speckled; quartz and quartzitic granules and pebbles abundant.
6.0	Concealed.
22.0	Sandstone, coarse grained, speckled; crude current bedding. Wave-cut base.
2.0	Shale, black, fissile, carbonaceous.
6.0	Concealed.
4.0	Sandstone, grey to dark grey, fine to medium grained; rough, thin flaggy bedding.
50.0	Concealed, mostly; few exposures of coarse grained, speckled sandstones and grits.
8.0	Sandstone, speckled, coarse grained; with grit layers.
8.0	Concealed.
14.0	Interbeds of coarse grained sandstones and grits, and fine to medium grained, concretionary, and cross bedded sandstones.
6.0	Sandstones, very coarse grained, speckled; with grits.
65.0	Concealed.
25.0	Concealed, in parts; few thick beds of speckled coarse to very coarse grained sandstones.
30.0	Concealed.
70.0	Sandstones, grey, medium grained, argillaceous, overlain by sandstones, lighter coloured, coarse grained, and cross bedded; in units 5 to 12 feet. These sequences separated by thin units of interbedded fine grained, grey sandstones, siltstones, dark grey shale, and carbonaceous shale.
	Brenva Formation — 397.0 feet
80.0	Concealed.
32.0	Sandstones, thick crude current bedding; and sandstones, grey, thin bedded, with siltstones and shale partings. One thin covered interval with carbonaceous shale, and small coal spoil.
205.0	Concealed.
26.0	Sandstones, fine to medium grained, thin flaggy bedded or ripple marked; with some thin interbeds of grey siltstone and dark grey shales. Much coalified plant debris.

Thickness (Feet)	Description
30.0	Concealed.
2.0	Sandstone, argillaceous, with thin shale partings; fine plant debris.
22.0	Concealed.
	Beaudette Group
	Monach Formation +263.3 feet
33.0	Quartzites, and conglomeratic quartzitic grits; pebbles of quartzite (maximum median diameter 3/8 inch).
18.0	Concealed.
38.0	Quartzite with lenses of quartzitic grit, and conglomeratic layers; granules and pebbles of quartzite.
65.0	Sandstones, clean, buff coloured, uniformly fine grained; with lenses of fine grained quartzites in upper part; few concealed parts.
60.0	Sandstones, clean, buff coloured, mostly fine grained and thick bedded; some concealed parts.
22.0	Sandstones, clean to moderately argillaceous, buff, mostly fine grained.
1.6 to 2.3	Sandstone, fine to very coarse grained, and grit; with several conglomeratic lenses; pebbles of quartzite and few of chert, to $\frac{1}{2}$ inch median diameter.
25.0	Sandstone, clean to moderately argillaceous, buff to light brownish coloured, fine grained.
	Concealed.

AREA OF THE BEATTIE PEAKS, MOUNTS MONTEITH AND FRANK ROY

In the Peace and Pine River Foothills, the formations of the Beaudette Group show their thickest development about a northeast-southwest axis passing through the area of the headwaters of Carbon Creek, as already noted. Good sections occur in this area at the Beattie Peaks, Mounts Monteith and Frank Roy. These were examined in a brief visit, as part of a reconnaissance of the Moberly Valley (1955). The area of the headwaters of Carbon Creek is a suitable type area for the Monteith, Beattie Peaks, and Monach Formations, but type sections are left undesignated in view of the limited study available to the writer. Section 10 and Figure 7 summarize and illustrate the Bullhead succession observed at the Beattie Peaks. Other points of stratigraphic interest are noted below.

The Monteith Formation can be traced to its lower contact with thinly interbedded shales, siltstones, and sandstones, which are placed in the transition beds of the Fernie Group. Thick beds of grey and brownish weathering sandstones separated by thin intervals (up to 3 feet) of shales, with siltstones and sandstones, compose most of the Monteith Formation. Quartzites are restricted to the upper third part in contrast to the eastern sections. The interbedding of quartzites and sandstones, also indicates that they form complementary lithofacies in the Monteith Formation. The contact with the Beattie Peaks Formation is marked by interfingering of sandstone beds with shales and siltstones at Mount Monteith, but elsewhere it appears to be more abrupt.

The lithology of the Beattie Peaks Formation is represented in Section 11,

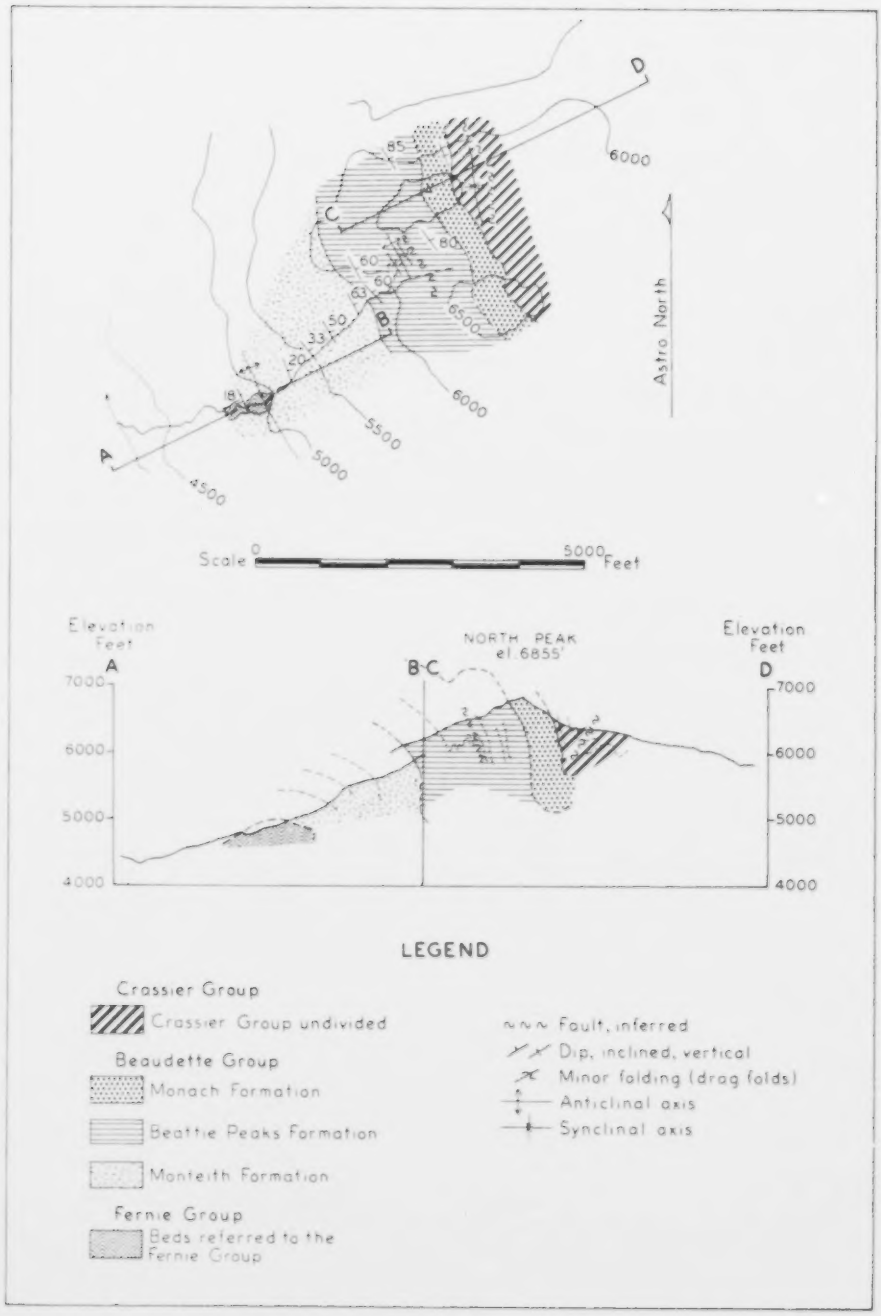


Figure 7. Beaudette Group and adjacent strata at the Beattie Peaks.

while Plate V illustrates its appearance and the nature of the thin bedding. Further details serve to identify the formation, namely; abundant ripple marking, with a span of about 3 inches, in the thin sandstones; horizons of (?) Dentalium, and fragments of pelecypod shells; layers of rounded and flattened clay galls in sandstones; occasional ironstone bands; thin partings of black, carbonaceous shale with "worm" markings and prints; brownish weathering colours of thin siltstones and sandstones. The formation was an incompetent unit in folding and deformation, being invariably disturbed by complex, subsidiary folds and faults in this area.

The Monach Formation is well developed. Sandstones of the lower member form thick beds, separated by a few thin units of interbedded shales, siltstones, and sandstones. The upper member is extensive, and represented by a single bed of quartzite with lenses of quartzitic grit. It is followed by the coal measures of the Crassier Group, but no clear section of this contact was found locally.

The Brenot and Dresser Formations can be separated satisfactorily in this area, although exposures are poor. On the east flank of Mount Monteith, the Dresser Formation contains 6 to 8 feet of chert pebble conglomerate at its base.

Section No. 10

The General Succession of the Crassier and Beaudette Groups at the Beattie Peaks

Thickness (Feet)	Description	
	Crassier Group	
	Brenot Formation	+250 feet
250.0	Mostly concealed, including: argillaceous and ferruginous sandstones, fine to medium grained, in thin beds; shales, carbonaceous shales, silty shales, and siltstones; silty mudstones with plant debris and rootlets. Some coal spoil.	
	Beaudette Group	
	Monach Formation	430 feet
30.0	Quartzites and quartzitic grit.	
400.0	Sandstones, medium to fine grained, weathering in buff colours, and with flaggy or platy habit. Thin layers of clay galls and shell fragments. Few intervals (less than 4 feet) of shales, with siltstone and sandstone. Buchia sp. indet.	
	Beattie Peaks Formation	1,200 to 1,250 feet
500.0	Thinly interbedded shales and silty shales, with laminae and partings of black, carbonaceous shale with "worm" markings and prints; siltstones; and sandstones, very fine grained. Ironstone bands. Sandstones, fine to medium grained, in beds 4 to 20 feet thick. Buchia sp. indet.	

Thickness (Feet)	Description
700.0 to 750.0	Thinly interbedded shales, siltstones, and sandstones, etc., as for the upper part. Ironstone bands. Few, thick sandstone beds.
	Monteith Formation 1,850 feet
600.0	Quartzites, fine to very coarse grained. Lesser quartzitic sandstones, and argillaceous sandstones fine to medium grained. Interbeds, 2 to 24 inches thick, of black shale and shales with thin silty and sandy partings, in thin interbeds.
1,250.0	Sandstones, in thick beds of 10 to 20 feet, fine to medium grained, variably argillaceous, grey and brown weathering colours. Some quartzitic sandstones, and few quartzites. Interbeds 2 to 24 inches thick of black and dark grey shales, with thin siltstones and sandstones.
	Fernie Group
	Transition Beds +80 feet
80.0	Thinly interbedded shales, and silty shales, siltstones, and fine grained sandstones; general brown weathering colour.
	Concealed.

Section No. 11

Detail of the Beattie Peaks Formation: Northeast Cirque of Mount Frank Roy, ½ Mile North of Summit

Thickness (Feet)	Description
	Beattie Peaks Formation
2.4	Shales, dark grey, silty and hackly shales, and siltstones; thin laminae and partings of black carbonaceous shales with "worm" markings.
1.3	Sandstone, grey, fine grained.
12.3	Thinly interbedded siltstones and shales, silty shales. Thin ironstone bands.
11.5	Thinly interbedded shales and silty shales with partings of black, carbonaceous shales bearing "worm" markings. Siltstones and very fine grained sandstones.
0.5	Ironstone band.
3.6	Shales, and silty shales, dark grey. Polyptychites (Polyptychites) cf. keyserlingi s.l.
7.4	Thinly interbedded shales, silty shales, and siltstone with laminae and partings of black carbonaceous shale, "worm" markings.
13.0	Shales, silty shales, and siltstones, with partings of black, carbonaceous shale, etc. Thin interbeds (1 to 14 inches thick) of very fine to fine grained sandstone.

Thickness (Feet)	Description
11.4	Concealed.
3.2	Thin interbedded siltstones and very fine grained sandstones, with lesser shales.
19.0	Concealed mostly, including: shales, siltstones, and thin sandstones.
3.0	Sandstone, fine grained, with thin shale partings.
15.0	Concealed.

Monteith Formation

PINE VALLEY: FISHER CREEK AND MOUNT BICKFORD

Bullhead strata form the major outcrop in the western Foothills of the Pine River, west of Crassier Creek. The succession, illustrated in Figures 8 and 9, is determined from mapping of the Pine Valley. Very few sections are at all complete, or well exposed. Fossils of stratigraphic value, found in mapping, are listed in Chapter II and are not reported here.

In the core of the Bickford anticline, the Monteith Formation contains 1,500 to 1,550 feet of beds, its base being concealed. Grey and brown weathering sandstones in the lower part pass to sandstones with quartzites in the upper 300 to 400 feet. The quartzites appear to be erratically distributed in this interval. Plate VI shows the Monteith-Beattie Peaks boundary.

The thickness of the Beattie Peaks Formation ranges from 650 to 775 feet across the Bickford anticline. The formation thickens to perhaps 950 feet at Big Boulder Creek further west, but here it contains more thick sandstone beds, and its boundaries are less distinct. Most of the outcrops are shown by a weathered remanié and talus of fragments, which are covered with black shale laminae bearing "worm" markings. Buchia faunas were obtained from clear exposures of thinly interbedded shales, siltstones, and fine grained sandstones.

Outcrops of the Monach Formation are not obvious everywhere, but the formation forms a distinct unit in good exposures (Section 12). In the lower member, sandstones are separated by only a few argillaceous beds, which are less than 4 feet thick. A variable development of the upper quartzite member is recorded: a single unit of quartzites with a wave swept base, in the east limb of the Bickford anticline; several quartzite beds separated by concealed intervals, between Fisher and Crassier Creeks; a 3-foot quartzite bed at the boundary of the Crassier and Beaudette Groups, observed on the west flank of Mount Bickford; an absence of quartzites at this stratigraphic boundary on the west limb of the Bickford anticline, south of the Pine River. The quartzite member, including concealed intervals, attains a maximum thickness of 130 feet. The Monach Formation is found to be 300 to 400 feet thick, where well exposed. The formation appears to be thinner, west of Mount Bickford, but this may be a surmise, for exposures are incomplete here.

The Brenot Formation of the Crassier Group overlies the Monach Formation directly (Section 12 and Plate I). Gradations and intertonguing of marine and non-marine strata have not been found about this boundary. If they exist, they must be confined to concealed intervals within the quartzite member, and therefore can be intermediate in age between the Monach sandstones and the Brenot Formation.

The Crassier Group is 3,700 feet thick in an unfaulted section on the east slopes of Fisher Creek; partial sections occur along the upper tributaries of the creek.

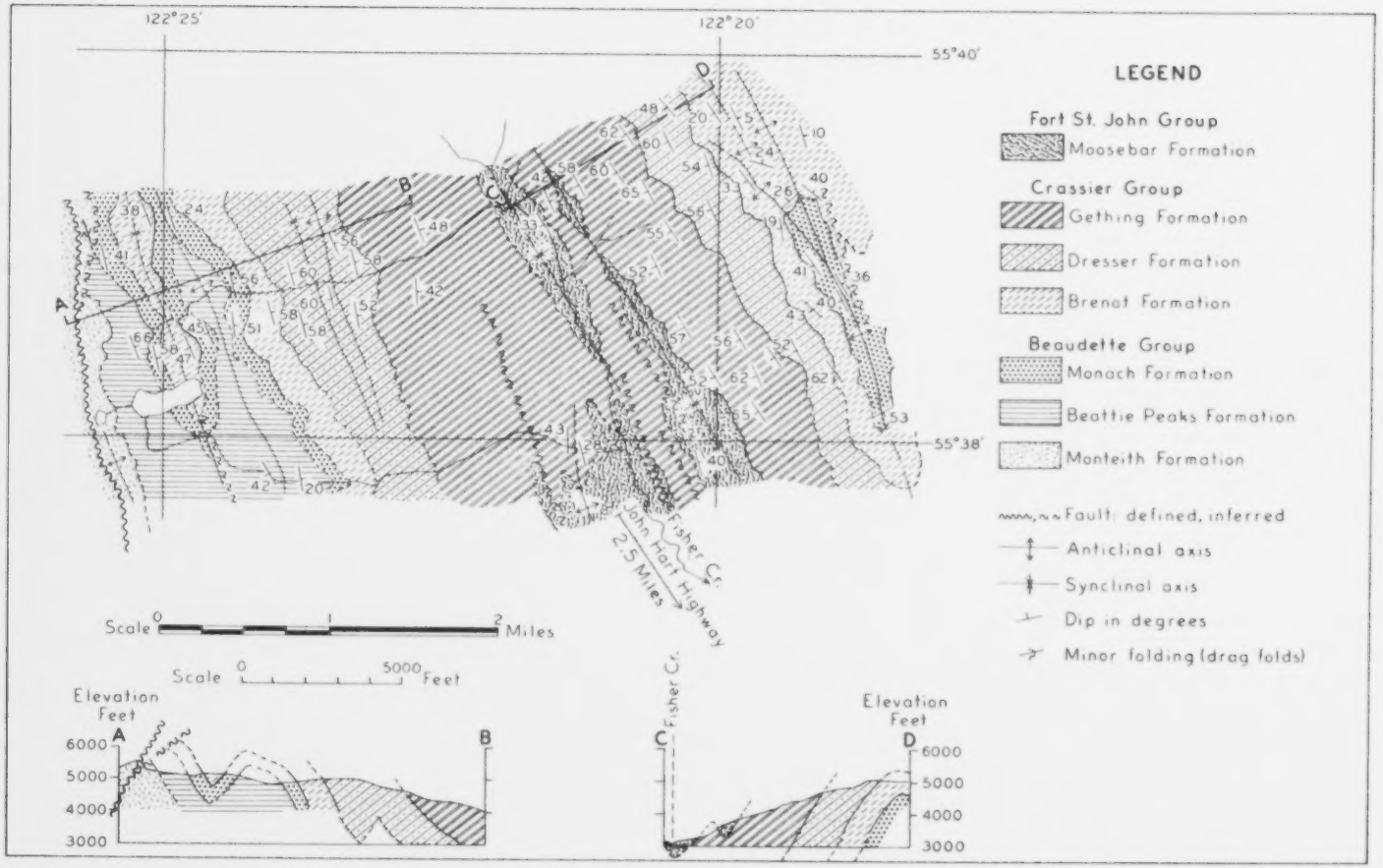


Figure 8. Part of the Fisher Creek area: Pine River Foothills.

The Brenot Formation is about 750 feet thick, the upper boundary being drawn at the first incoming of medium to very coarse grained sandstones and grits in thick beds. The formation is poorly exposed, and is usually marked by debris of thin, rust coloured sandstone plates on the high ground. Shales, mudstones, and thin coals can be found by searching the gullies alongside the creeks. Section 12 describes the character of the formation. Locally, on the east side of Fisher Creek, cyclothems of sandstones, siltstones, shales, mudstones, and carbonaceous shales, lacking coals or with only few thin coal partings, are present in the upper part of the formation. A similar group of barren cyclothems occurs in the comparable stratigraphic position at Rainbow Rocks.

The Dresser Formation is mapped from the outcrops of medium to very coarse grained sandstones with grits and conglomerate. The intervening coal measures, including fine to medium grained sandstones, compose about two-thirds of the formation. Section 13 represents most of the features of the Dresser Formation in this area. A few conglomerates, more than 10 feet thick, are present; they contain pebbles of chert and fewer of quartzite, usually less than 1 inch in diameter. Coarse grained sandstones and conglomerates rest on eroded and scoured surfaces of the coal measure sequences, and contain imprints and fragments of coarse plant debris and woody material, together with shale and mudstone inclusions at their base. A thickness of 1,200 feet is assigned to the Dresser Formation in the Fisher syncline.

The Gething Formation, about 1,750 feet thick, is poorly exposed in this area. It can be seen in places along the creek walls, and these reveal sequences of shales, mudstones, siltstones, sandstones, coal seams, together with clay ironstone banding. The formation includes much fine to medium grained sandstone in the lower 600 feet. Its boundary with the Dresser Formation, defined arbitrarily, seems less obvious in outcrop than in the eastern sections.

Section No. 12

Section of the Beattie Peaks, Monach, and Brenot Formations from a Rock Cut of the Pacific Great Eastern Railway, 2 Miles Southwest of Beaudette Creek, Pine Valley

Thickness (Feet)	Description	
	Crassier Group	
	Brenot Formation	+241.1 feet
8.2	Interbedded shales, dark grey, siltstones, and fine grained sandstones; passing to shales in lower part.	
	Shale, black, carbonaceous--parting.	
0.3	Coal.	
0.2	Siltstone, tough, unbedded; coarse plant debris.	
4.2	Interbedded shales, siltstones, and fine grained sandstones.	
0.5	Shale, dark grey.	
12.5	Sandstones, very fine to fine grained, with interbeds of siltstone and shale.	
2.3	Shale, dark grey, with siltstones.	
5.5	Sandstone, very fine grained, with interbeds of shale.	

Thickness (Feet)	Description
3.3	Shale, dark grey, with siltstone partings.
0.2	Shale, black, fissile.
1.6	Sandstone, very fine to fine grained.
3.7	Interbedded shales, siltstones, and sandstones, very fine to fine grained.
0.4	Sandstone.
	Coal--parting; washed out in places.
0.9	Shale, passing upward to mudstone, with plant "rootlets" and fragments.
4.7	Sandstone, very fine to fine grained, ripple marked; shale and siltstone partings.
2.5	Shale, black, fissile, and carbonaceous; passing up to shale, dark grey, rubbly.
0.6	Siltstone, argillaceous, sandy, and unbedded; much coarse plant debris.
2.3	Sandstone, fine grained; with shale partings.
0.2	Shale, black, fissile, carbonaceous.
0.3	Coal.
0.7	Mudstone, with plant fragments; silty in lower part.
7.5	Interbedded sandstones, siltstones, and shales.
5.3	Siltstones and very fine grained sandstones, with lesser shales.
4.6	Shale, dark grey, with thin siltstones and sandstones in upper part.
0.2	Shale, black, carbonaceous.
0.4	Shale, dark grey, with silty and sandy partings.
3.0	Sandstone, fine to medium grained; inclusions and partings of shale.
3.7	Shale, dark grey, with thin siltstones and very fine grained sandstones.
0.5	Shale, black, fissile, carbonaceous.
1.0	Coal; deformed.
0.3	Siltstone, argillaceous, unbedded; plant debris.
11.0	Sandstone, very fine to fine grained; ripple marked; containing thin interbeds of shales and siltstones.
21.0	Shales, dark grey mostly; with thin sandstones, in minor amount.
17.2	Sandstone, fine grained, some medium grained parts; grey and speckled appearance. Inclusions of shale fragments, and ironstone pebbles. Partings of shale, and layers with plant debris.
9.2	Sandstone, very fine grained; with siltstones and thin shales.
1.5	Siltstones, with shales.
1.7	Sandstone, very fine grained, with thin siltstones.
1.2	Shale, black to dark grey, fissile, carbonaceous.
1.8	Coal, with middle shaly parting.
0.3	Mudstone; with coarse plant debris.
1.0	Siltstone, argillaceous, sandy, unbedded; with rootlets.
6.0	Sandstone, fine grained; minor shales and siltstones.
13.5	Shale, dark grey; with thin interbeds of siltstones and sandstones.
6.8	Sandstone, fine grained, ripple marked; minor shales in thin interbeds.
8.3	Sandstone, fine to medium grained; containing fragments of shales, with angular, lenticular, and subrounded outlines; slump bedded, with bending of shale inclusions.

Thickness (Feet)	Description
0.2	Shale.
17.5	Sandstone, fine to medium grained, containing fragments of shale, with angular, subrounded, and lenticular outlines, and clay ironstone pebbles.
0.2	Shale, with coaly and sandy partings.
1.3	Coal, deformed; deeply weathered.
0.8	Mudstone, coarse plant debris.
36.0	Sandstone, fine to medium grained; grey, and partly speckled appearance; containing shale fragments of angular to subrounded outlines, and few clay ironstone pebbles. Few, thin interbeds of shales with siltstones.
3.0	Coal, deeply weathered; resting on irregular surface of quartzite.
	Beaudette Group
	Monach Formation 377.0 feet
42.0	Quartzite, fine to very coarse grained; clean cut contact at base.
92.0	Sandstone, fine to medium grained, with a few lenses of coarser grained sandstones; grey in fresh cuts, weathering in light buff colours.
8.0	Interbedded sandstone and dark grey shale.
123.0	Sandstone, fine to medium grained; some coarser grained parts; weathering in light buff colours.
112.0	Sandstones, mostly fine to medium grained; few fragments of belemnites.
	Beattie Peaks Formation + 60.1 feet
3.8	Shales and silty shales, dark brownish grey; with thin partings and interbeds of siltstone and fine grained sandstone.
5.1	Sandstone, fine to medium grained.
0.6	Shale, with siltstone and sandstone partings.
6.7	Sandstone, fine to medium grained.
5.3	Shales; concealed parts.
6.5	Sandstone, fine to medium grained.
0.8	Shales, with siltstones.
3.3	Sandstone, fine to medium grained.
0.8	Shales, with siltstones and thin sandstones.
5.3	Sandstone, fine to medium grained.
8.2	Shales, dark grey; with thin laminae and interbeds of siltstones and fine grained sandstones.
2.7	Sandstone, fine grained; with shale partings.
11.0	Shales, dark grey; with laminae of siltstones and sandstones; few thin sandstones. Concealed parts.

Section No. 13

Representative Section of the Dresser Formation: Fisher Creek

Location: 4 miles north of the Cleveland Creek Bridge, and 3½ miles west-northwest

of Fisher Creek Bridge, along the John Hart Highway; at elevations 4,150 to 4,350 feet on a tributary creek entering Fisher Creek from the east.

(Section from the interval 300 to 600 feet above the base of the formation.)

Thickness (Feet)	Description
+15.0	Sandstone, grey, fine to coarse grained; crudely bedded.
4.0	Concealed.
2.2	Sandstone, conglomeratic; pebbles of chert, and few quartzites, and shale fragments. Scoured base.
1.6	Sandstone, conglomeratic; chert pebbles to $\frac{3}{4}$ inch diameter.
7.8	Sandstone, coarse to very coarse grained; scattered chert pebbles and thin conglomeratic layers.
0.7	Conglomerate; chert pebbles to 1 inch diameter.
6.0	Sandstone, coarse grained; scattered chert and quartzite pebbles.
4.0	Concealed.
4.5	Sandstone, fine grained, ripple marked and thin, platy bedded; with silty laminations. Including thin interbeds of dark grey shale in lower part.
23.0	Concealed.
2.3	Sandstone, fine grained, argillaceous, with fine plant debris. Wave cut base.
1.1	Shale, black, carbonaceous.
0.5	Mudstone, dark brown, with clay ironstone nodules.
19.0	Mostly concealed; some thinly interbedded sandstones, siltstones, and shales.
1.2	Sandstones with thin siltstones.
2.3	Shales, dark grey, with silty layers.
10.6	Interbedded shales, siltstones, and fine grained sandstones with shale inclusions.
0.8	Siltstone, blackish, carbonaceous, tough, unbedded.
0.4	Shale, black with thin coal partings.
4.5	Interbedded shales, siltstones, and sandstones; some concealed parts.
6.0	Sandstone, brown weathering, fine grained, ripple marked; passing to--
16.5	Sandstone, medium to very coarse grained, with grits; speckled appearance due to coarse, light and dark coloured chert grains. Scoured base.
0.2	Shale, dark grey, silty; band of black, fissile, carbonaceous shale at base.
0.3	Coal.
0.3	Shale, black, fissile, carbonaceous, much plant debris; passing to--
0.6	Mudstone, dark grey, with coarse, coalified, wood fragments.
1.5	Shale, black, fissile, carbonaceous; passing to--
2.6	Shales, black and silty, brownish grey shales with clay ironstone nodules.
14.5	Interbedded shales, dark grey, and sandstones, fine grained, ripple marked; some concealed parts.
18.0	Sandstone, speckled, coarse to very coarse grained; with grits; crudely marked current bedding; some concealed parts.
9.0	Concealed.
2.7	Sandstone, fine grained, ripple marked; with clay galls.

Thickness (Feet)	Description
0.3	Shale, dark grey, silty.
3.7	Concealed.
11.2	Interbedded shales and sandstones, fine grained, ripple marked, and containing clay galls.

PINE VALLEY: COYOTE CREEK WESTWARDS TO CAIRNS CREEK, AND THE NORTH SALIENT OF MOUNT Le MORAY

The Beaudette Group west of Big Boulder Creek in the Pine Valley shows the result of facies changes. These changes attributed to the thinning and virtual disappearance of the quartzites of the Monteith Formation, and to an increasing proportion of sandstones in the Beattie Peaks Formation, are mostly appreciable from mapping, for sections are not well exposed, or otherwise incomplete. No satisfactory distinctions of the Monteith, Beattie Peaks, and Monach Formations can be made, as for example in the ground west of Little Boulder Creek. The Beaudette Group here contains about 3,150 feet of beds forming part of a thrust block, but they are not regarded as exotic (Figure 9). (Movement on the thrust probably did not exceed 5 miles, and Beaudette, Fernie, and Triassic beds are in continuous stratigraphic order in folds at the rear, or southwest, of the thrust.)

Beaudette strata in the north salient of Mount Le Moray are described in Section No. 14. They outcrop in a syncline and overlie faulted and disharmonically folded beds of the Fernie Group. The lowermost 1,350 feet of beds, yielding Buchia faunas of Tithonian-Berriasian age, are correlatable with the Monteith Formation, but the overlying beds remain uncorrelated from palaeontological evidence. This section is incomplete due to erosion.

The Crassier Group west of Mount Bickford is mapped as an undivided unit. In its lower part, it contains more sandstone beds than the equivalent Brenot Formation of the eastern Foothills. Locally, on the west flank of the Bickford anticline, a thick conglomerate occurs about 850 feet above the base of the coal measures. Here, and to the west, little can be seen of the equivalent of the Dresser Formation. Medium to very coarse grained sandstones and grits exposed in this interval are widely spaced, and do not allow grouping into a natural stratigraphic unit. It seems inadvisable to assume a distinction of the Brenot and Dresser Formations in the 2,500 to 3,000 feet of coal measures outcropping between Mount Bickford and Little Boulder Creek.

Section No. 14

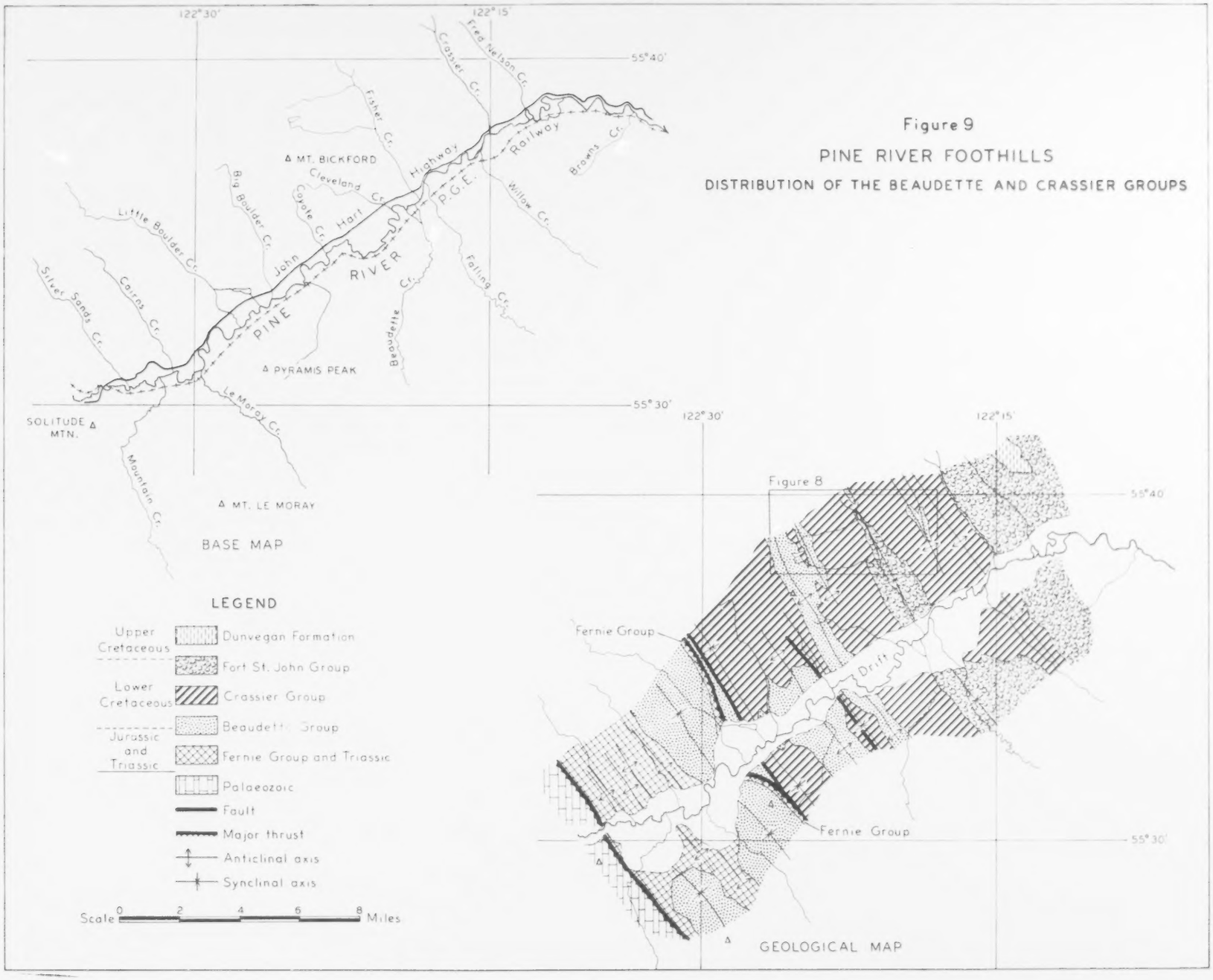
Section of the Undivided Beaudette Group: From the North Salient of Mount LeMoray, Pine Valley

Thickness (Feet)	Description	
	Beaudette Group	+ 2,250 feet
450	Sandstones, brown weathering, fine and medium grained, with chert grains; argillaceous, grey, quartzitic sandstones, with few quartzitic grits; lesser	

Figure 9

PINE RIVER FOOTHILLS

DISTRIBUTION OF THE BEAUDETTE AND CRASSIER GROUPS



Thickness (Feet)	Description
	shales brown and dark grey, siltstones and silty mudstones; concealed parts. Many of the sandstones are conglomeratic--containing angular to rounded phenoclasts of shale and mudstone, and clay galls also.
275	Sandstones, buff and brown weathering; light grey, clean quartzitic sandstones, fine to coarse grained. Few layers of shale and mudstone phenoclasts, and clay galls.
175	Sandstones, buff and grey coloured, fine to medium grained, thick bedded; brown, argillaceous and ferruginous sandstones, as for underlying interval.
	Fauna: Lot (iv) - float 1,350 to 1,500 feet above base Buchia sp. indet. (of early Lower Cretaceous affinities) Buchia ? sp. indet. Pecten (Pseudamusium ?) sp. indet.
1,325	Sandstones, brown weathering, argillaceous and ferruginous, with dark coloured chert grains; some concretionary banding. Few layers of clay galls, and of clay galls with shell fragments, and scattered pebbles of chert and quartzite. Minor, thin interbeds of shales and siltstones, dark grey.
	Fauna: Lot (iii) - float about 1,300 to 1,350 feet above base Buchia cf. okensis (Pavlow) Buchia cf. uncitoides (Pavlow) s.l. Buchia sp. indet. Arctica ? sp. indet. Lot (ii) - float about 1,000 to 1,075 feet above base Buchia ex aff. B. fischeriana (d'Orbigny) and B. okensis (Pavlow) Buchia n. sp. ex aff. B. volgensis (Lahusen) Lot (i) - float about 25 to 100 feet above base Buchia sp. indet. (of uppermost Jurassic or lowermost Cretaceous affinities) Tellina ? sp. indet.
25	Sandstones in thick and thin beds. Talus and concealed parts.
	Fernie Group
	Locally concealed.

CHAPTER IV.--ECONOMIC GEOLOGY

COAL

Large reserves of coal occur in the Crassier Group. More lately, they have been investigated and reported by McLearn and Irish (1944), Spivak (1944), Mathews (1947), McLearn and Kindle (1950), and McKechnie (1955). The coals are of good quality, mostly of medium to low volatile bituminous rank, and include some with good coking qualities. Analyses show low ash and sulphur, and high calorific value for a large proportion of samples. Most mineable seams occur in the upper half, the Gething and the upper part of the Dresser Formation. Few seams attain a thickness of 5 feet, in the eastern outcrops. In the southwest, in the Pine River Foothills, seven seams are known to exceed a thickness of 10 feet (see McKechnie, 1955); the seams designated vary in character, and contain bone and non-coaly interbeds and partings. The coal resources of the Peace and Pine River Foothills are virtually confined to the Crassier Group. Coal supplies a small market in northeastern British Columbia, and now faces competition from other sources of fuel, oil and gas, which are locally produced and refined. The importance of coal mining has declined, but a small annual production has been maintained at the Gething and Reschke mines near Hudson Hope (Minister of Mines and Petroleum Resources, B.C., Ann. Repts., 1960, 1961).

OIL AND GAS

The "Schedule of Wells Drilled for Oil and Natural Gas in British Columbia (1961)" lists thirteen fields capable of producing gas, and four fields capable of producing oil from Bullhead strata (including the Bluesky-Gething unit), in the Plains, south of latitude 57 degrees 30 minutes north. The oil and gas are enclosed in structural, stratigraphic, and combined traps in the subsurface of the Plains. Conditions favouring stratigraphic traps in the subsurface of the Plains can be envisaged from this work. They apply to the Bullhead succession as follows:

(1) Eastward and away from the Peace and Pine River Foothills, the Crassier Group may include porous sandstones in tongues and bars of littoral origin. Sandstones of non-marine origin, found in outcrop, are non-porous.

(2) The marine retreat ending Beaudette sedimentation probably left local accumulations of littoral sands, which were subsequently enclosed by non-marine strata. Such deposits would correspond to the quartzite member of the Monach Formation.

(3) If proven, a disconformity between the Crassier and Beaudette Groups may entrap oil and gas, particularly where the underlying beds are overlapped or overstepped. Porosity in beds below disconformities (or unconformities) is often developed by former subaerial weathering, and by posthumous leaching at such contact.

(4) In the Monteith Formation, and equivalent strata, the proportion of quartzites increases, from west to east across the Foothills. The porosity of the quartzites, erratic in nature and due to incomplete cementation by secondary quartz, increases correspondingly. These trends suggest that the Monteith Formation may allow oil and gas entrapment under the Plains.

(5) Impermeable beds, shales, mudstones, argillaceous siltstones, and sandstones are numerous enough to provide seals.

The Bluesky Formation of the subsurface plains is the correlative of the basal conglomerate and sandstone of the Moosebar Formation (Fort St. John Group), and

presumably may follow the Gething Formation with disconformity in this area (see account by Pugh, 1960).

The stratigraphy of the Bullhead indicates suitable conditions for oil and gas entrapment. A search for these conditions (1 to 4 of the list) should aid exploration and development work, in the subsurface of the Plains and the adjacent parts of the Foothills.

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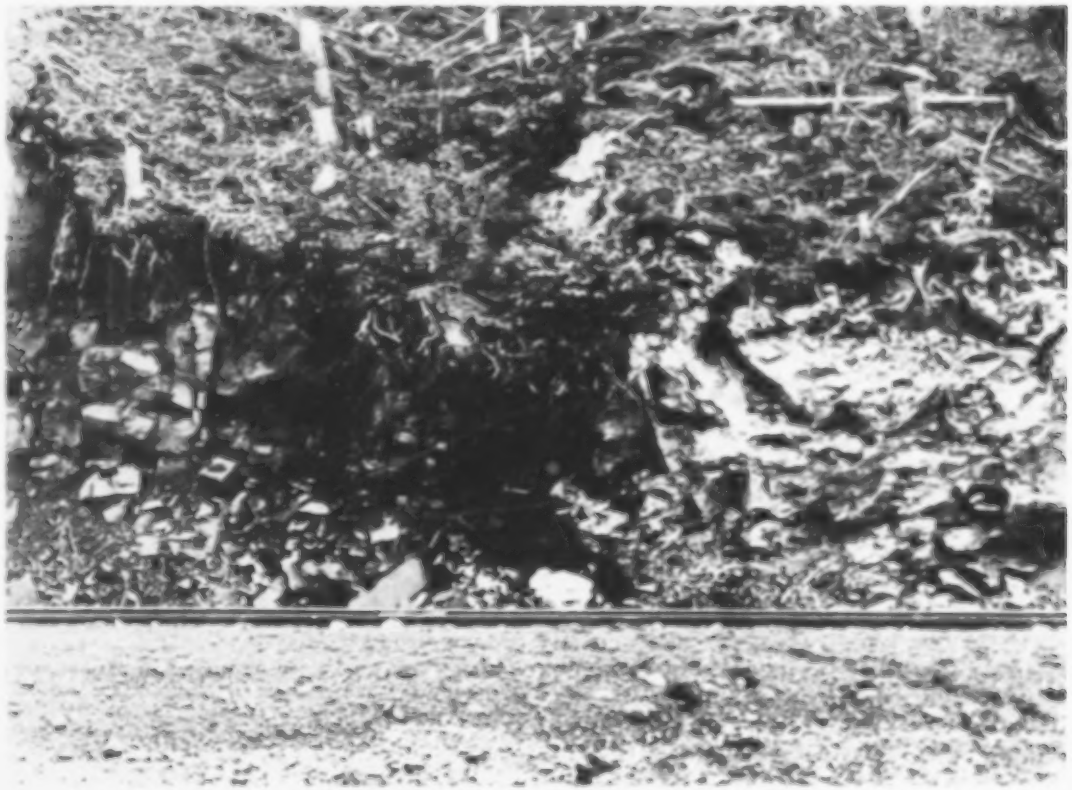

Plate I.--The boundary of the Beaudette and Crassier Groups in the east limb of the Bickford anticline, south bank of the Peace River, in a rock cut of the Pacific Great Eastern Railway 2 miles southwest of Beaudette Creek. Quartzites of the upper member of the Monach Formation overlain by coal measures of the Brenot Formation on left. Hammer marks weathered coal seam (see Section No. 12).

Plate II.--Part of the Peace River Canyon under the abandoned Peace River mine, 1 mile downstream from the entry of the Canyon. Type section of the Dresser Formation (Section No. 7). The Larry (Creek) sandstone at the top of the middle view marks the upper boundary of the Dresser Formation. Photographed in 1959, this face now forms the north abutment of the main dam across the Peace River at the Portage Mountain Damsite.

Plate III.--The Peace River Canyon, view downstream from the wall shown in Plate II. The Gething Formation, exposed in the south (right) wall of the Canyon, overlies the Dresser Formation, shown lower right. Photographed in 1959.

Plate IV.--Sandstones of the Monach Formation on the west slope of Mount Frank Roy.

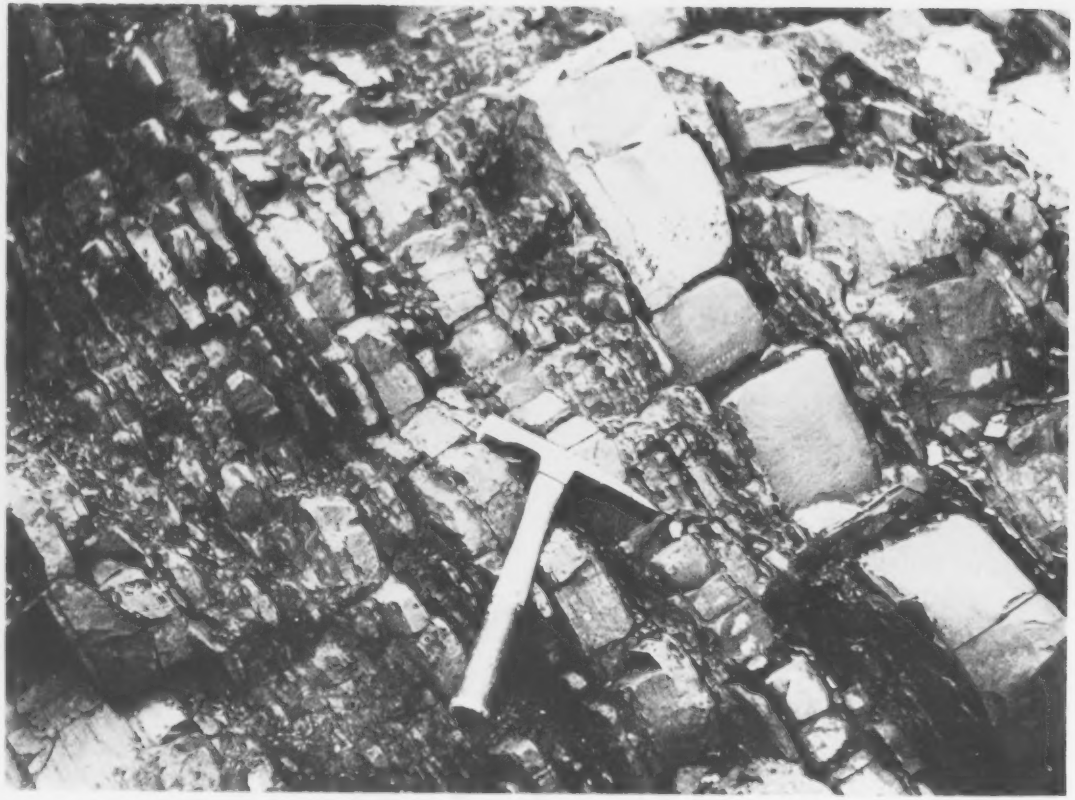

Plate V.--Detail of the Beattie Peaks Formation; thinly interbedded shales, siltstones, and sandstones; ironstone band (bottom right corner). From the lower 200 feet of the formation, along a creek draining southwest from the twin peaks of the Beattie Peaks.

Plate VI.--The ridge of Mount Bickford: Beattie Peaks Formation on the left, and Monteith Formation on the right (northeast). Locality, 1.4 miles southeast from the summit.